This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

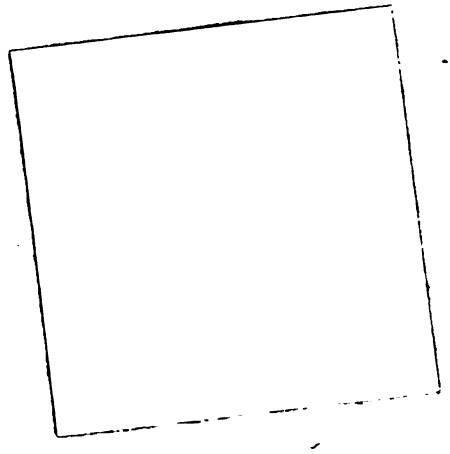
+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

The Branner Geological Library

LELAND·STANFORD·JVNIOR·VNIVERSITY



DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 622

MINERAL RESOURCES OF ALASKA

REPORT ON PROGRESS OF INVESTIGATIONS IN 1914

BY

ALFRED H. BROOKS AND OTHERS

WASHINGTON
GOVERNMENT PRINTING OFFICE
1915

283410

STANFORD LIBRARY

CONTENTS.

	Page.
Preface, by A. H. Brooks	5
Administrative report, by A. H. Brooks	7
The Alaskan mining industry in 1914, by A. H. Brooks	15
The future of gold placer mining in Alaska, by A. H. Brooks	69
Tin mining in Alaska, by H. M. Eakin	81
Mining in the Juneau region, by H. M. Eakin	95
Mineral deposits of the Kotsina-Kuskulana district, with notes on mining in Chitina Valley, by F. H. Moffit	103
Auriferous gravels of the Nelchina-Susitna region, by Theodore Chapin	118
Mining on Prince William Sound, by B. L. Johnson	131
The gold and copper deposits of the Port Valdez district, by B. L. Johnson	140
Mineral resources of the Chisana-White River district, by S. R. Capps	189
Mining in the Fairbanks district, by H. M. Eakin	229
Mining in the Hot Springs district, by H. M. Eakin	239
Mineral resources of the Lake Clark-Iditarod region, by P. S. Smith	247
Quicksilver deposits of the Kuskokwim region, by P. S. Smith and A. G. Maddren	272
Gold placers of the lower Kuskokwim, with a note on copper in the Russian Mountains, by A. G. Maddren	292
Iron-ore deposits near Nome, by H. M. Eakin	361
Placer mining in Seward Peninsula, by H. M. Eakin	366
Index	375
Recent Survey publications on Alaska	1

ILLUSTRATIONS.

		Page.
PLATE	I. Map showing location of Healy River	50
	II. Sketch map showing distribution of tin in Alaska	82
	III. Map of York tin region, Seward Peninsula	90
	IV. Map showing mineral resources of lower Copper River region	104
	V. Geologic sketch map of the Kotsina-Kuskulana district	106
	VI. Geologic sketch map of the Nelchina-Susitna region	124
	VII. Map of Prince William Sound, showing mineral resources	138
	VIII. Map of the Port Valdez district, showing mines and prospects	186
	IX. Sketch map of Chisana district, showing distribution of rock formations and location of mines and prospects	202
	X. Sketch map of Kuskokwim region, showing geology and mineral resources	270
	XI. Map of Tuluksak-Aniak placer district	350
FIGURE	1. Map showing location of Livengood Creek, Tolovana district	52
	2. Longitudinal section of cassiterite lobe, showing surface profile and underground developments	86
	3. Sketch map showing location of placers in the Nelchina region	126
	4. Geologic sketch map of the vicinity of Sawmill Bay	144
	5. Index map showing location of Chisana-White River district	189
	6. Map showing distribution of placers and igneous rocks in the vicinity of Iditarod	259
	7. Sketch map of the underground development at Parks quicksilver prospect	277
	8. Generalized section of bluff on Kuskokwim River about 5 miles below Kolmakof	283

MINERAL RESOURCES OF ALASKA, 1914.

By ALFRED H. BROOKS and others.

PREFACE.

By ALFRED H. BROOKS.

This volume contains a condensed summary both of the results of the investigations of Alaskan mineral resources during 1914 and of the status of the mining industry in the Territory. It is the eleventh of a series of annual bulletins[1] devoted to this subject. The chief purpose of this volume is to give prompt publication to the most important economic results of the year's investigations. This necessitates to a certain extent the curtailment of office studies, and hence some of the statements here presented may be subject to modification when the researches have been completed. Those interested in any particular district are therefore urged to procure a copy of the complete report on that district as soon as it is available.

Attempt has been made in this report to present more complete data on mineral production than in those previously issued. Unfortunately the accuracy of the statistical data is impaired by the fact that some of the mine operators, notably the placer miners, fail to report their production. Were it not for the public spirit shown by many residents of the Territory it would not be possible to prepare figures on the mineral production of many of the districts or to summarize the mining development. There are now nearly 450 operators who furnish information on mineral production and mining development. To these the writer desires to express his obligations. In addition to these operators many residents of the Territory have furnished valuable data of a general character relative to statistics of mineral production and mining development. Those who have thus rendered aid include many mine operators, engineers, prospectors,

[1] Report on progress of investigations of the mineral resources of Alaska, 1904 [to 1914]: U. S. Geol. Survey Bull. 259 [284, 314, 345, 379, 442, 480, 520, 542, and 592].

Federal officials, and officers of banks and of transportation and commercial companies. It is impossible to enumerate all who have contributed information, but special acknowledgment should be made to the Director of the Mint; Thomas Riggs, jr., of the Alaskan Engineering Commission; Wells Fargo & Co.; the Alaskan Mexican Gold Mining Co.; Alaska United Gold Mining Co.; and Alaska Treadwell Gold Mining Co., of Treadwell; Stephen Birch, of Kennecott; Melvin Dempsey, of Chistochina; the late Thomas L. Hanmore, of Iliamna; E. R. Stivers, of Fortymile; T. E. Phillips, of Jack Wade; John R. Kemp, of Steel Creek; J. J. Hillard, of Eagle; N. B. Nelson, of Chisana; William J. Reynolds, of Deadwood; Frank A. Reynolds, of Circle; American Bank, First National Bank, A. Bruning, and J. A. Fairborn, of Fairbanks; George W. Ledger and W. B. Ballou, of Rampart; John Hackanson, of Bonnifield; Northern Commercial Co. and O. R. Williams, of Nolan; Alexander Cameron, of Poorman Creek; A. S. Kinzer, of Ruby; Harry Fathergill, of Innoko; C. P. Wood and E. A. Austin, of Iditarod; E. R. Stivers, of St. Michael; R. W. J. Reed, of Nome; G. A. Adams, of Council City; F. A. Thomas, of Shelton; George Jamme, of Lost River; and E. E. Patterson, of Kotzebue.

The arrangement and manner of treatment in this volume are the same as in those previously issued. First, papers of a general character are presented, followed by those treating of special districts, arranged geographically from south to north. This bulletin contains eighteen papers by eight authors. One of these papers deals with administrative matters, one is a general summary of the mining industry, one treats of the future of the placer-mining industry, and the remainder deal more specifically with the mineral resources of certain districts. In the geologic papers emphasis is laid on the conclusions having immediate interest to the miner. These conclusions are discussed here briefly, but will be more fully treated in reports now in preparation. The need of prompt publication requires that the illustrations in this volume be of the simplest kind.

ADMINISTRATIVE REPORT.

By Alfred H. Brooks.

INTRODUCTION.

Under date of April 6, 1914, $100,000 was appropriated for the continuation of the investigation of the mineral resources of Alaska. The availability of the funds at this early date made it possible to start the field work promptly and to carry it on economically, these conditions being in strong contrast to those of the two previous years, when the delay in the appropriations greatly hampered the field work and made it very expensive.

Ten parties in all were engaged in surveys and investigations in 1914 from June until October. These parties included 11 geologists, 4 topographers, and 25 packers, cooks, and other assistants. Six parties were engaged in geologic work, two in topographic surveys, and two combined both classes. The results are summarized below.

The area covered by exploratory geologic surveys, on a scale of 1:500,000 (8 miles to the inch), was 1,200 square miles; by reconnaissance geologic surveys, on a scale of 1:250,000 (4 miles to the inch), 7,700 square miles; by detailed geologic surveys, on a scale of 1:62,500 (1 mile to the inch), 325 square miles. Much of the time of the geologists was devoted to the investigation of special field problems in the important mining districts, the results of which can not be presented in terms of area. About 600 square miles was covered by exploratory topographic surveys, on a scale of 1:500,000 (8 miles to the inch); 10,900 square miles by reconnaissance topographic surveys on a scale of 1:250,000 (4 miles to the inch); and 10 square miles by surveys on a scale of 1:24,000 (2.64 inches to 1 mile).

To state the work geographically, one topographic party was in southeastern Alaska, one geologic party in the Chitina basin, one topographic-geologic party in the Nelchina-Susitna region, one geologic party in the Prince William Sound region, one topographic-geologic party in the Lake Clark-Iditarod region, one geologic party in the lower Kuskokwim region, and one topographic and one geologic party in the Chisana-White River district. One party investigated the tin deposits of York and the mining developments near Nome, Fairbanks, and Juneau. Another party was engaged in geologic studies in southeastern Alaska, in the Chitina Valley, and along the Yukon.

Among the important results of the year were the tying together of the reconnaissance surveys of the Copper and Susitna basins and the carrying of a geologic and topographic survey from Lake Clark to the Iditarod. The latter work coordinates the previous surveys of the Iliamna region and on Cook Inlet with the work in the interior and the Iditarod district. A detailed study of the geology and mineral resources of the Kotsina district, in the Chitina region, was also completed. Important results were also obtained bearing on the general geology of the Mesozoic terranes of Alaska.

The following table shows the allotment, including both field and office expenses, of the total appropriation of $100,000 to the districts investigated. In addition to this, a balance of about $6,000 left from last year's appropriation was expended in equipping the parties for the season's field work. In preparing this table the general office expenses were divided among the districts in proportions determined by the cost of the surveys in each district, allowance being made for variations in the character of the work. The results are expressed in round numbers. The "general investigations" include the cost of special studies of geology and mineral resources which were not of an areal character. The unallotted balance will be used for equipment of field parties and expenses up to the close of the fiscal year 1915.

Approximate geographic distribution of appropriation for Alaska investigations, 1914.

Southeastern Alaska	$6,000
Copper and Susitna basins	25,000
Prince William Sound	6,500
Kuskokwim and Mulchatna river basins	22,000
White and Chisana river basins	14,000
Yukon basin	2,000
Seward Peninsula	1,500
General field and office investigations	12,000
Unallotted	11,000
	100,000

In the following table the approximate amount of money devoted to each class of investigations and surveys is indicated. It is not possible to give the exact figures, as the same party or even the same man may have carried on two different kinds of work, but this statement will help to elucidate a later table, which will summarize the complete areal surveys.

Approximate allotments to different kinds of surveys and investigations, 1914.

Geologic and topographic exploration	$4,400
Geologic reconnaissance surveys	13,000
Detailed geologic surveys	15,600
Special geologic investigations	13,000

Reconnaissance topographic surveys	$22,500
Detailed topographic surveys	4,300
Collection of statistics	1,400
Miscellaneous, including administration, inspection, clerical salaries, office supplies and equipment, and map compilation	14,800
Unallotted	11,000
	100,000

Allotment for salaries and field expenses, 1914.

Scientific and technical salaries	$36,530
Field expenses	36,715
Clerical and other office and miscellaneous expenses	15,755
Unallotted	11,000
	100,000

The following table exhibits the progress of investigations in Alaska and the annual grant of funds since systematic surveys were begun in 1898. It should be noted that a varying amount is spent each year on special investigations, yielding results which can not be expressed in terms of area.

Progress of surveys in Alaska, 1898–1914.

Year.	Appropriation.	Areas covered by geologic surveys.			Areas covered by topographic surveys.[a]					Investigations of water resources.	
		Exploratory (scale 1:625,000 or 1:1,000,000).	Reconnaissance (scale 1:250,000).	Detailed (scale 1:62,500).	Exploratory (scale 1:625,000 or 1:1,000,000).	Reconnaissance (scale 1:250,000; 200-foot contours).	Detailed (scale 1:62,500 and larger; 25, 50, or 100 foot contours).	Lines of levels.	Bench marks set.	Gaging stations maintained part of year.	Stream volume measurements.
		Sq. mi.	*Sq. mi.*	*Sq. mi.*	*Sq. mi.*	*Sq. mi.*	*Sq. mi.*	*Miles.*			
1898	$46,189	9,500	.....	.....	12,840	2,070	.....	.....	.....	.....	.....
1899	25,000	6,000	.....	.....	8,690	.....	.....	.....	.....	.....	.....
1900	60,000	3,300	6,700	.....	630	11,150	.....	.....	.....	.....	.....
1901	60,000	6,200	5,800	.....	10,200	5,450	.....	.....	.....	.....	.....
1902	60,000	6,950	10,050	.....	8,330	11,970	96	.....	.....	.....	.....
1903	60,000	5,000	8,000	96	.....	15,000	.....	.....	.....	.....	.....
1904	60,000	4,050	3,500	.....	800	6,480	480	86	19	.....	.....
1905	80,000	4,000	4,100	536	.....	4,880	787	202	28	.....	.....
1906	80,000	5,000	4,000	421	.....	13,500	40	.....	.....	14	286
1907	80,000	2,600	1,400	442	.....	6,120	501	95	16	48	457
1908	80,000	2,000	2,850	604	.....	3,980	427	76	9	53	556
1909	90,000	6,100	5,500	450	6,190	5,170	444	.....	.....	81	703
1910	90,000	.....	8,635	321	.....	13,815	36	.....	.....	69	429
1911	100,000	8,000	10,550	496	.....	14,460	246	.....	.....	68	309
1912	90,000	.....	2,000	525	.....	.....	298	.....	.....	69	381
1913	100,000	3,500	2,950	180	3,400	2,535	287	.....	.....	24	185
1914	100,000	1,000	7,700	325	600	10,300	10	.....	.....	.....	.....
	1,261,189	73,200	83,735	4,396	51,680	126,880	3,652	450	72	.....	.....
Percentage of total area of Alaska	.....	12.48	14.28	0.75	8.81	21.64	0.62	.....	.....	.....	.....

[a] The Coast and Geodetic and International Boundary surveys and the General Land Office have also made topographic surveys in Alaska. The areas covered by these surveys are, of course, not included in these totals.

Among the important results of the year were the tying together of the reconnaissance surveys of the Copper and Susitna basins and the carrying of a geologic and topographic survey from Lake Clark to the Iditarod. The latter work coordinates the previous surveys of the Iliamna region and on Cook Inlet with the work in the interior and the Iditarod district. A detailed study of the geology and mineral resources of the Kotsina district, in the Chitina region, was also completed. Important results were also obtained bearing on the general geology of the Mesozoic terranes of Alaska.

The following table shows the allotment, including both field and office expenses, of the total appropriation of $100,000 to the districts investigated. In addition to this, a balance of about $6,000 left from last year's appropriation was expended in equipping the parties for the season's field work. In preparing this table the general office expenses were divided among the districts in proportions determined by the cost of the surveys in each district, allowance being made for variations in the character of the work. The results are expressed in round numbers. The "general investigations" include the cost of special studies of geology and mineral resources which were not of an areal character. The unallotted balance will be used for equipment of field parties and expenses up to the close of the fiscal year 1915.

Approximate geographic distribution of appropriation for Alaska investigations, 1914.

Southeastern Alaska	$6,000
Copper and Susitna basins	25,000
Prince William Sound	6,500
Kuskokwim and Mulchatna river basins	22,000
White and Chisana river basins	14,000
Yukon basin	2,000
Seward Peninsula	1,500
General field and office investigations	12,000
Unallotted	11,000
	100,000

In the following table the approximate amount of money devoted to each class of investigations and surveys is indicated. It is not possible to give the exact figures, as the same party or even the same man may have carried on two different kinds of work, but this statement will help to elucidate a later table, which will summarize the complete areal surveys.

Approximate allotments to different kinds of surveys and investigations, 1914.

Geologic and topographic exploration	$4,400
Geologic reconnaissance surveys	13,000
Detailed geologic surveys	15,600
Special geologic investigations	13,000

Reconnaissance topographic surveys	$22,500
Detailed topographic surveys	4,300
Collection of statistics	1,400
Miscellaneous, including administration, inspection, clerical salaries, office supplies and equipment, and map compilation	14,800
Unallotted	11,000
	100,000

Allotment for salaries and field expenses, 1914.

Scientific and technical salaries	$36,530
Field expenses	36,715
Clerical and other office and miscellaneous expenses	15,755
Unallotted	11,000
	100,000

The following table exhibits the progress of investigations in laska and the annual grant of funds since systematic surveys were gun in 1898. It should be noted that a varying amount is spent ch year on special investigations, yielding results which can not be pressed in terms of area.

Progress of surveys in Alaska, 1898–1914.

ear.	Appropriation.	Areas covered by geologic surveys.			Areas covered by topographic surveys.a					Investigations of water resources.	
		Exploratory (scale 1:625,000 or 1:1,000,000).	Reconnaissance (scale 1:250,000).	Detailed (scale 1:62,500).	Exploratory (scale 1:625,000 or 1:1,000,000).	Reconnaissance (scale 1:250,000; 200-foot contours).	Detailed (scale 1:62,500 and larger; 25, 50, or 100 foot contours).	Lines of levels.	Bench marks set.	Gaging stations maintained part of year.	Stream volume measurements.
		Sq. mi.	*Sq. mi.*	*Sq. mi.*	*Sq. mi.*	*Sq. mi.*	*Sq. mi.*	*Miles.*			
.....	$46,189	9,500	.....	.....	12,840	2,070	.....	.....	.....	.....	.....
.....	25,000	6,000	.....	.....	8,690	.....	.....	.....	.....	.....	.....
.....	60,000	3,300	6,700	.....	630	11,150	.....	.....	.....	.....	.....
.....	60,000	6,200	5,800	.....	10,200	5,450	.....	.....	.....	.....	.....
.....	60,000	6,950	10,050	.....	8,330	11,970	96	.....	.....	.....	.....
.....	60,000	5,000	8,000	96	.....	15,000	.....	.....	.....	.....	.....
.....	60,000	4,050	3,500	.....	800	6,480	480	86	19	.....	.....
.....	80,000	4,000	4,100	536	.....	4,880	787	202	28	.....	.....
.....	80,000	5,000	4,000	421	.....	13,500	40	.....	.....	14	286
.....	80,000	2,600	1,400	442	.....	6,120	501	95	16	48	457
.....	80,000	2,000	2,850	604	.....	3,980	427	76	9	53	556
.....	90,000	6,100	5,500	450	6,190	5,170	444	.....	.....	81	703
.....	90,000	.....	8,635	321	.....	13,815	36	.....	.....	69	429
.....	100,000	8,000	10,550	496	.....	14,460	246	.....	.....	68	309
.....	90,000	.....	2,000	525	.....	.....	298	.....	.....	69	381
.....	100,000	3,500	2,950	180	3,400	2,535	287	.....	.....	24	185
.....	100,000	1,000	7,700	325	600	10,300	10	.....	.....	.....	.....
	1,261,189	73,200	83,735	4,396	51,680	126,880	3,052	450	72	.....	.....
ent- e of tal ea of laska.	.....	12.48	14.28	0.75	8.81	21.64	0.62	.....	.....	.....	.....

The Coast and Geodetic and International Boundary surveys and the General Land Office have also le topographic surveys in Alaska. The areas covered by these surveys are, of course, not included hese totals.

GEOGRAPHIC DISTRIBUTION OF INVESTIGATIONS.

GENERAL WORK.

The writer was engaged in office work until July 6, when he started for Alaska. A conference was held with Mr. Witherspoon at Juneau, and B. L. Johnson's camp at Valdez was reached on July 22. A week was devoted to a study of local geology with Mr. Johnson and Mr. Harrington. The journey was then continued to Mr. Moffit's camp on the Kotsina, and here a week was spent with him and Mr. Mertie on the local geology. It had been planned to proceed direct to Fairbanks by private automobile from Chitina, but as this plan failed a delay was occasioned by waiting for transportation. Through the courtesy of Col. W. P. Richardson the journey from Chitina to McCarthy was made with him in the Alaska Road Commission's autotruck. No difficulties were encountered in the use of the machine, as the wagon road was in excellent condition. The heavy rains had washed out two bridges between McCarthy and Fairbanks, making the use of the truck impractical on this stretch of the road. Therefore the journey was continued on the Quartermaster Department steamer *General Jacobs*, and Fairbanks was reached on August 30. Some 12 days were then devoted to a study of some features of the local geology, partly in company with H. H. Bennett, of the Bureau of Soils. The return trip to Seattle was made by way of Dawson, and Washington was reached on October 7.

During the calendar year 1914 the geologist in charge devoted 31 days of his time in the office to geologic studies, 27 days to reading and revising manuscripts, 26 days to preparation of progress report, 19 days to mineral statistics, 14 days to matters relating to railways in Alaska and Alaska coal leasing, 8 days to field plans, 8 days to Panama-Pacific Exposition work, 7 days to preparation of the annual press bulletin on mining in Alaska, and the rest to routine matters.

George C. Martin was engaged during the summer in investigating the Mesozoic stratigraphy of Alaska. His results will be of great importance in correlating Mesozoic terranes and in the deciphering of the geologic history of Alaska. Mr. Martin, accompanied by R. M. Overbeck as assistant, left Washington on June 6 and returned on October 9, having visited localities in southeastern Alaska and in the Chitina and Yukon valleys.

R. H. Sargent continued the general supervision of the topographic surveys and map compilation, in addition to carrying on his own field work. E. M. Aten continued as office assistant to the geologist in charge and supervised the office work during the writer's absence in the field. He also continued to assist in collecting statistics of production of precious metals in Alaska.

SOUTHEASTERN ALASKA.

The very extensive mining developments in the Juneau district led to a demand for a revision of the surveys in this area. The base map of Juneau and its environment was completed in 1902 and the geologic survey of the same area in the following year, but the recent developments have made available much additional information about the geology and occurrence of the metalliferous deposits. For these reasons a resurvey was justified, and in view of the fact that Juneau promises to be one of the most important gold-producing camps on the continent it was decided to make a large-scale base map.

The scale adopted, 1:24,000 (about 2.64 inches to the mile), is the same as that used in the important mining camps of the Western States. The making of a detailed map of this kind under the best of conditions is very laborious, and the difficulties were much increased by the ruggedness of the topography, the heavy underbrush, and the large number of rainy days. D. C. Witherspoon was detailed for this work and spent the time from May 27 to October 12 in the Juneau district. Of this time it rained 45 days to the extent of totally prohibiting surveys, but in spite of the adverse conditions Mr. Witherspoon did the necessary triangulation and mapped 9.75 square miles.

In 1913 the systematic geologic survey of the Ketchikan district was undertaken, but owing to other demands this work was not continued in 1914. It is to be again taken up in 1915. C. W. Wright's detailed report on the "Geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska" (Professional Paper 87) was issued in May, 1915.

COPPER RIVER AND SUSITNA BASIN.

The detailed geologic mapping of the west end of the Kotsina-Chitina copper belt began in 1912 but, being interrupted in 1913, was not completed until 1914. F. H. Moffit, assisted by J. B. Mertie, began work in this district June 10 and continued until September 30. During this time they mapped the geology and studied the mineral resources of an area of 185 square miles. A preliminary statement of results is contained in this volume, and the complete report is in preparation.

A topographic reconnaissance survey was carried by J. W. Bagley from Copper Center to the head of Klutina River and thence northwest to the Susitna. Work was begun on June 25 and concluded on October 11, and in this time an area of 4,000 square miles was surveyed by phototopographic methods on a scale of 1:250,000, with 200-foot contours. Theodore Chapin, who accompanied the party as

geologist, mapped an area of about 3,600 square miles. He also examined the gold placers of the Nelchina basin. This survey forms an important connecting link between previous surveys in the Copper, Susitna, and Matanuska valleys. The principal economic results are summarized in this volume, and a complete report is in preparation.

PRINCE WILLIAM SOUND.

A detailed geologic survey and study of mineral resources of Port Valdez district was begun in 1914, and it is hoped will be completed in 1915. B. L. Johnson, assisted by G. L. Harrington, was assigned to this project, began work on June 19, continued until October 6, and covered an area of 140 square miles. He also spent a few days in the Port Wells district. The economic results are presented in this volume.

LAKE CLARK-IDITAROD REGION.

As there was a large, almost unknown region lying between Lake Clark and the Iditarod district, an exploration of this field was undertaken in 1914. The party, under the leadership of R. H. Sargent, topographic engineer, and P. S. Smith, geologist, also included five camp men and was equipped with 20 horses. Work was begun on June 20 at Lake Clark, and a survey was carried through to Iditarod, which was reached September 10. The topographic surveys covered an area of 4,800 square miles and the geologic surveys 3,500 square miles. Some of the quicksilver deposits of the Kuskokwim were examined. The economic results are summarized in this volume and a complete report is in preparation.

LOWER KUSKOKWIM BASIN.

There are several placer-gold districts in the lower Kuskokwim basin where mining has been carried on for several years. Plans were made for investigating these districts in 1913 but could not be carried out because of the lateness of the appropriation. In 1914 these plans were put into execution. A. G. Maddren, assisted by Burt Kennedy, arrived at Iditarod on July 6 and then went overland to Kuskokwim River. The route then lay down that river and up several tributary streams. The Aniak and Tuluksak placer districts were examined. The field work closed at Bethel on September 23, and from that point the party returned to Seattle by gasoline schooner. During the season exploratory topographic surveys were made of about 600 square miles and geologic surveys of about 1,000 square miles. Besides the gold placers, some copper and quicksilver deposits were also examined. Preliminary statements of results are included in this volume, and a more complete report is in preparation.

SEWARD PENINSULA.

In view of important developments in the York tin district, a supplementary examination of this field was undertaken by H. M. Eakin, who devoted about 15 days to this work and to the investigation of the mining developments near Nome, including a brief study of the iron deposits in the Sinrock basin, about 40 miles from Nome. The results are presented elsewhere in this volume.

YUKON BASIN.

The development of gold placers in the Chisana district, in the upper Tanana region, made an examination of this field desirable. C. E. Giffin was detailed to extend the topographic surveys in this region. Field work began on June 12 and was continued until August 23. A survey was made of Skolai Pass, and the previous mapping in the Tanana and White River basins was extended eastward to the boundary. A reconnaissance was thus carried over an area of about 1,500 square miles for publication on a scale of 1:250,000. In addition to this, about 1,500 square miles of the old mapping was revised. The wagon road from Willow Creek to Chitina, a distance of 40 miles, together with the adjacent country, was also surveyed in the fall, making an additional area of revision of about 150 square miles. S. R. Capps at the same time made a geologic study of the Chisana placer district and mapped the geology of an area of about 600 square miles. His field work began June 10 and closed September 5. A summary of results is presented in this volume.

The writer's own field work near Fairbanks has already been referred to. H. M. Eakin devoted about three weeks to the investigation of the mining developments at Hot Springs and Fairbanks.

COLLECTION OF STATISTICS.

The collection of statistics of the production of precious metals was continued as in previous years. Mine operators have shown a willingness to cooperate in this work by furnishing promptly a statement of mineral production. There are still a number who fail to make returns, thereby decreasing the accuracy of the figures on production for the different districts. In the absence of complete information, the statistics are still in part based on estimates made on the basis of information procured from various sources. Practically all the gold and copper lode operators furnish statements of production, but the returns from placer mines are still far from being complete.

PUBLICATIONS.

During 1914 the Survey published two bulletins relating to Alaska. One professional paper, two bulletins, and one water-supply paper were in press at the end of the year. In addition the authors' work on three bulletins and one water-supply paper is completed, and these will soon be sent to press. Four reports are in progress. One map to be issued separately is in press, and the compilation of a new general map is nearly completed.

REPORTS ISSUED.

BULLETIN 578. The Iditarod-Ruby region, Alaska, by H. M. Eakin; including geologic and topographic reconnaissance maps. (Issued in September, 1914.)

BULLETIN 592. Mineral resources of Alaska: Report on progress of investigations in 1913, by Alfred H. Brooks and others. (Issued in October, 1914.)

REPORTS IN PRESS.

PROFESSIONAL PAPER 87. Geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska, by C. W. Wright; including detailed geologic and topographic maps. (Issued in May, 1915.)

BULLETIN 576. Geology of the Hanagita-Bremner region, Alaska, by F. H. Moffit; including topographic and geologic reconnaissance maps. (Issued in January, 1915.)

BULLETIN 587. Geology and mineral resources of Kenai Peninsula, Alaska, by G. C. Martin, B. L. Johnson, and U. S. Grant; including geologic and topographic reconnaissance maps. (Issued in July, 1915.)

WATER-SUPPLY PAPER 342. Surface water supply of the Yukon-Tanana region, Alaska, by C. E. Ellsworth and R. W. Davenport; illustrated by topographic reconnaissance maps. (Issued in May, 1915.)

REPORTS FOR WHICH ILLUSTRATIONS ARE BEING PREPARED.

BULLETIN 605. The Ellamar district, Alaska, by S. R. Capps and B. L. Johnson.

BULLETIN 607. The Willow Creek district, Alaska, by S. R. Capps.

BULLETIN 608. The Broad Pass region, Alaska, by F. H. Moffit, with sections on Quaternary deposits, igneous rocks, and glaciation by J. E. Pogue.

WATER-SUPPLY PAPER 372. A water-power reconnaissance in south-central Alaska, by C. E. Ellsworth and R. W. Davenport.

REPORTS IN PREPARATION.

Geology of the Glacier Bay and Lituya region, Alaska, by F. E. Wright and C. W. Wright, including geologic reconnaissance map.

Geology of the region along the international boundary from Porcupine River to the Arctic Ocean, by A. G. Maddren, including detailed geologic map.

The Yukon-Koyukuk region, by H. M. Eakin.

The upper Matanuska basin, by G. C. Martin.

MAPS PUBLISHED SEPARATELY.

Port Valdez district, by J. W. Bagley and C. E. Giffin; scale, 1:62,500; contour interval 50 feet. (Published in April, 1915.)

General map of Alaska; scale, 1:1,500,000. (Published in May, 1915.)

THE ALASKAN MINING INDUSTRY IN 1914.

By Alfred H. Brooks.

GENERAL CONDITIONS.

The certainty of railroad connection with the Yukon basin and the probability of an early development of the coal fields greatly stimulated the search for mineral deposits in Alaska during 1914. This advance was offset in a measure by the low price of copper and the financial depression resulting from the European war. The mining industry of the Territory can, as a whole, be said to have had a prosperous year, though the value of the total mineral output is somewhat less than that of 1913. This was due largely to the decrease in the price of copper, for the gold output was a little larger than that of the previous year.

A noteworthy feature of the mining industry in 1914 was the great number of investigations that were made on behalf of capitalists looking for properties that would warrant development on a large scale. This was true in nearly all the mining districts, but, as was to be expected, it was more pronounced in the south-central region, which will be directly benefited by the building of the Government railroad. With the consequent opening of the coal fields we can now look forward with confidence to the early establishing of copper smelters in the coastal districts, and possibly at no distant day to the utilization of some of the iron ores. The choice of the Seward-Fairbanks route, with a branch to the Matanuska coal field, having been announced, the regions thus served will probably receive the earliest development, but that the trans-Alaska line is expected to benefit other parts of the Territory is indicated by important developments undertaken in southeastern Alaska, in Seward Peninsula, and other districts remote from any railroad route under consideration. The new railroad will undoubtedly, directly or indirectly, benefit all parts of the Territory. The regions tributary to the proposed line will receive the direct benefit, but other regions will obtain cheaper fuel. Moreover, the project will attract population and capital to other parts of the Territory, especially to those parts that are already served by the existing railways or water transportation.

Outside of the Government railroad project there was little change during the year in the transportation system of Alaska. Some of the existing lines were operated, including the White Pass, Copper River & Northwestern, and Tanana Valley railroads and part of the line of the Alaska Northern Railway. The Alaska Northern line has now been purchased by the Government. The Alaska Road Commission continued its important work of constructing wagon roads and trails.

The installation of dredges has continued chiefly on Seward Peninsula, but to a lesser extent in the Yukon basin. The high price of fuel has in a large measure discouraged the utilization of dredges on the extensive deposits of auriferous gravels in the Fairbanks and other inland districts that can not be profitably mined by the methods now in use. Quartz mining at Fairbanks is almost at a standstill for the same reason. On the other hand, the auriferous lode mines on or near the coast made notable advances during the year, especially in the Juneau, Port Wells, and Willow Creek districts. In southeastern Alaska the utilization of the water powers, both for mining and other industries, made notable advance in 1914.

Although the actual production of copper was less than in 1913, the copper-mining industry made greater advances in 1914 than in any previous year. Large copper developments were under way during the year in the Ketchikan, Prince William Sound, and Chitina districts, though these were in a measure curtailed when the copper market became demoralized after hostilities began in Europe. There is good reason to believe that the copper output of 1915 will be larger than that of any previous year.

The development of both lode and placer tin deposits in the York district of Seward Peninsula was continued. There was also an increase in the amount of placer tin recovered from the Hot Springs gold placers.

There was no change in the coal-mining situation during the year, though the passage of the leasing law stimulated interest in Alaskan coal fields. The Katalla field produced some oil in 1913, but in the absence of any hope of obtaining title or lease of oil lands there was no prospecting except on patented claims. Marble and gypsum deposits were worked in southeastern Alaska, as in previous years, and some beginning was made in the opening up of barite deposits.

PRODUCTION.

The value of the total mineral production of 1914 is estimated at $19,118,080; in 1913 it was $19,476,356. The statistics for 1914 are

not yet complete, and the figures given in the subjoined table may be subject to slight change. The output of marble, gypsum, petroleum, and other minor products is given under a single item because separate listing might reveal the production of individual properties.

Mineral production of Alaska, 1913 and 1914.

	1913		1914		Increase (+) or decrease (−).	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Gold.....fine ounces..	755,947	$15,626,813	762,596.03	$15,764,259	+ 6,649.03	+$137,446
Silver.....do....	362,563	218,988	394,805	218,327	+ 32,242	− 661
Copper.....pounds..	21,659,958	3,357,293	21,450,628	2,852,934	−209,330	− 504,359
Tin.....tons of metallic tin..	69	44,103	104	66,560	+ 35	+ 22,457
Coal.....short tons..	2,300	13,800	.....	.....	− 2,300	− 13,800
Marble, gypsum, lead, petroleum, etc.....	.....	215,359	.....	216,000	.....	+ 641
	.....	19,476,356	.....	19,118,080	.....	− 358,276

Productive mining began in Alaska in 1880, when the Juneau gold placers were first exploited. It is estimated that since that time mineral wealth has been produced to the value of $268,151,936. This output by years and by substances is summarized in the following table:

Value of total mineral production of Alaska, 1880–1914.[a]

By years.		By years.		By substances.	
1880-1890.....	$4,686,714	1904.....	$9,569,715	Gold.....	$244,156,799
1891.....	916,920	1905.....	16,480,762	Silver.....	2,278,518
1892.....	1,098,400	1906.....	23,378,428	Copper.....	19,780,452
1893.....	1,051,610	1907.....	20,850,235	Tin.....	380,006
1894.....	1,312,567	1908.....	20,145,632	Lead.....	67,142
1895.....	2,388,042	1909.....	21,146,953	Coal.....	361,189
1896.....	2,981,887	1910.....	16,887,244	Marble, gypsum, petroleum, etc.....	1,127,830
1897.....	2,540,401	1911.....	20,691,241		
1898.....	2,587,815	1912.....	22,536,849		268,151,936
1899.....	5,706,226	1913.....	19,476,356		
1900.....	8,241,734	1914.....	[b]19,118,080		
1901.....	7,010,838				
1902.....	8,403,153		268,151,936		
1903.....	8,944,134				

[a] Some slight changes from those previously published have been made in this table.
[b] Preliminary estimate.

The following table is an estimate of the total production of gold, silver, and copper since the beginning of auriferous mining in 1880. For the earlier years, and this is especially true of the silver, the figures are probably far from being correct, but they are based on the best information now available.

Production of gold, silver, and copper in Alaska, 1880–1914.

Year.	Gold.		Silver.		Copper.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Commercial value.	Quantity (pounds).	Value.
1880	967	$20,000				
1881	1,935	40,000				
1882	7,256	150,000				
1883	14,561	301,000				
1884	9,728	201,000	10,320	$11,146	3,933	$826
1885	14,512	300,000				
1886	21,575	446,000				
1887	32,553	675,000				
1888	41,119	850,000	2,320	2,181	.....	.....
1889	43,538	900,000	8,000	7,490	.....	.....
1890	36,862	762,000	7,500	6,071	.....	.....
1891	43,538	900,000	8,000	7,920	.....	.....
1892	52,245	1,080,000	8,000	7,000	.....	.....
1893	50,213	1,038,000	8,400	6,570	.....	.....
1894	62,017	1,282,000	22,261	14,257	.....	.....
1895	112,642	2,328,500	67,200	44,222	.....	.....
1896	138,401	2,861,000	145,300	99,087	.....	.....
1897	118,011	2,439,500	116,400	70,741	.....	.....
1898	121,760	2,517,000	92,400	54,575	.....	.....
1899	270,997	5,602,000	140,100	84,276	.....	.....
1900	395,030	8,166,000	73,300	45,494	.....	.....
1901	335,369	6,932,700	47,900	28,598	250,000	40,000
1902	400,709	8,283,400	92,000	48,590	360,000	41,400
1903	420,069	8,683,600	143,600	77,843	1,200,000	156,000
1904	443,115	9,160,000	198,700	114,934	2,043,586	275,676
1905	756,101	15,630,000	132,174	80,165	4,805,236	749,617
1906	1,066,030	22,036,794	203,500	136,345	5,871,811	1,133,260
1907	936,043	19,349,743	149,784	98,857	6,308,786	1,261,757
1908	933,290	19,292,818	135,672	71,906	4,585,362	605,267
1909	987,417	20,411,716	147,950	76,934	4,124,705	536,211
1910	780,131	16,126,749	157,850	85,239	4,241,689	538,695
1911	815,276	16,853,256	460,231	243,923	27,267,878	3,408,485
1912	829,435	17,145,951	515,186	316,839	29,230,491	4,823,031
1913	755,947	15,626,813	362,563	218,988	21,659,958	3,357,293
1914	762,596	15,764,259	394,805	218,327	21,450,628	2,852,934
	11,811,084	244,156,799	3,851,406	2,278,518	133,404,063	19,780,452

In the following table the total production of gold is distributed according to districts so far as the information at hand will permit. The error in the distribution of total production previous to the year 1905, when systematic collection of Alaska's mineral output was begun, is believed to be less than 15 per cent. Complete statistical returns from all producers are not even now available, so that there is probably still some error in the distribution of the totals to the various districts. This error is, however, believed to be less than 3 per cent, and it is hoped that in future it may be eliminated altogether.

The production from the Pacific coast belt is derived principally from the lode mines of southeastern Alaska, but includes also the output of the lode mines of Prince William Sound and southwestern Alaska, as well as a small output from gold placers. Previous to 1885 the placers of the Juneau district yielded considerable gold, and since 1899 the Porcupine district of southeastern Alaska has been a small producer. The beach placers along the Pacific seaboard have been worked spasmodically since about 1890.

Up to 1909 all the gold from the Copper River and Cook Inlet region was derived from gold placers; since then there has been an output from the auriferous lodes of Willow Creek and Kenai Peninsula. The gold output of Seward Peninsula is practically all derived from placers, and although there has been a little lode mining on the peninsula, none was done in 1914. Since 1910 there has been a small lode production from the Fairbanks district, which in 1914 amounted to about 6 per cent of the total.

Since 1909 some gold has been recovered each year from placers in the lower Kuskokwim basin. In the table which follows this is included in the output of the Yukon basin. It should be noted that the figures for the Yukon gold output include only the Alaska camps and not the Klondike and other Canadian districts.

Value of gold production of Alaska, with approximate distribution, 1880–1914.

Year.	Pacific coast belt.	Copper River and Cook Inlet region.	Yukon basin.	Seward Peninsula and northwestern Alaska.	Total.
1880	$20,000				$20,000
1881	40,000				40,000
1882	150,000				150,000
1883	300,000		$1,000		301,000
1884	200,000		1,000		201,000
1885	275,000		25,000		300,000
1886	416,000		30,000		446,000
1887	645,000		30,000		675,000
1888	815,000		35,000		850,000
1889	860,000		40,000		900,000
1890	712,000		50,000		762,000
1891	800,000		100,000		900,000
1892	970,000		110,000		1,080,000
1893	838,000		200,000		1,038,000
1894	882,000		400,000		1,282,000
1895	1,569,500	$50,000	709,000		2,328,500
1896	1,941,000	120,000	800,000		2,861,000
1897	1,799,500	175,000	450,000	$15,000	2,439,500
1898	1,892,000	150,000	400,000	75,000	2,517,000
1899	2,152,000	150,000	500,000	2,800,000	5,602,000
1900	2,606,000	160,000	650,000	4,750,000	8,166,000
1901	2,072,000	180,000	550,000	4,130,700	6,932,700
1902	2,546,600	375,000	800,000	4,561,800	8,283,400
1903	2,843,000	375,000	1,000,000	4,465,600	8,683,600
1904	3,195,400	500,000	1,300,000	4,164,600	9,160,000
1905	3,430,000	500,000	6,900,000	4,800,000	15,630,000
1906	3,454,794	332,000	10,750,000	7,500,000	22,036,794
1907	2,891,743	275,000	9,183,000	7,000,000	19,349,743
1908	3,448,318	401,500	10,323,000	5,120,000	19,292,818
1909	4,264,716	265,000	[a]11,580,000	4,302,000	20,411,716
1910	4,182,730	351,630	[a]8,062,389	3,530,000	16,126,749
1911	4,265,573	313,538	[a]9,139,145	3,135,000	16,853,256
1912	4,904,753	358,401	[a]8,857,797	3,025,000	17,145,951
1913	4,529,529	378,643	[a]8,183,641	2,535,000	15,626,813
1914	4,538,157	597,681	[a]7,895,421	2,735,000	15,764,259
	70,450,313	6,008,393	99,055,393	68,642,700	244,156,799

[a] Includes a small proportion from the Kuskokwim basin.

The subjoined table is an estimate, based on the best available data, of the source of the gold, silver, and copper produced in Alaska since mining began in 1880. About $65,100,000 worth of gold, or nearly a third of the total output, was produced previous to 1905,

and there is but scant information about its source. Since that time fairly complete statistics of production are available, and it is believed that the figures here presented are near enough to the truth to have value. The figures given in this table for the silver recovered from placer gold and from siliceous ores are probably less accurate than those for the gold. Copper mining did not begin in Alaska until 1901, and the figures for gold and silver from this source should therefore be a close approximation to the actual output.

Estimate of sources of gold and silver in Alaska, 1880–1914, by kinds of ore.

	Gold.		Silver.	
	Quantity.	Value.	Quantity.	Value.
	Fine ounces.		*Fine ounces.*	
Siliceous ores	3,264,787	$67,489,141	894,847	$612,533
Copper ores	46,181	954,666	1,462,348	840,029
Placers	8,500,116	175,712,992	1,494,311	825,956
	11,811,084	244,156,799	3,851,506	2,278,518

Tin mining began in Alaska in 1902, since when about 526 tons of metallic tin has been recovered, valued at $380,006. (See pp. 81–94.) Most of this has been taken from the placers of the York district, of Seward Peninsula, but there has been a little tin lode mining in the same district. Some stream tin has also been recovered from the gold placers of Hot Springs district, in the lower Tanana region.

There has been relatively little mining of galena ores as such, but some lead has been recovered in the treatment of ores mined chiefly for other metals. The first treatment of such galena-bearing ores was in 1892, and since that time 796 tons of lead, valued at $67,142, has been recovered. It is worthy of record here that galena deposits were among the first lodes to be developed in Alaska. Galena was found in the Fish River basin, in the eastern part of Seward Peninsula, in 1881,[1] about the time of the discovery of the Treadwell lode at Juneau. Here some developments were made at what was called the Omalik mine as early as 1882. Some ore has been shipped from this property, but the mine has never been on a regular productive basis.

The only other galena ores mined in Alaska are located in southeastern Alaska. These operations, which have been on only a small scale, were on deposits[2] located on Cholmondeley Sound, an indentation of the eastern shore of Prince of Wales Island, and on Coronation Island, which lies in the lower end of Lynn Canal.

[1] Smith, P. S., and Eakin, H. M., A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, Alaska: U. S. Geol. Survey Bull. 449, p. 130, 1911.

[2] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska: U. S. Geol. Survey Bull. 347, 1908.

There has been a little mining of cinnabar on the lower Kuskokwim since 1908. The cinnabar has been treated at the mine in a small retort, and the total recovery from this industry has been about 700 pounds of quicksilver.

Besides that listed above, there has been no production of other metals from Alaska on a commercial scale, though some test shipments of iron and antimony ores have been made.

The first coal mining in Alaska was done on Kachemak Bay,[1] Cook Inlet, in 1888. Since that time 47,969 short tons of coal has been produced, valued at $362,029. This is practically all lignite, except for a few thousand tons of bituminous coal mined on Bering Lake in 1906–7. During the epoch of railway building at Katalla in 1908 some petroleum was pumped from the oil wells near by for local use as fuel. Since 1912 an oil company has operated in the Katalla field and made an annual production.

Marble has been produced in southeastern Alaska since 1901 to a total value of about $650,000. A gypsum deposit on Chichagof Island, in southeastern Alaska, has been operated on a productive basis since 1905. There has been some mining of garnet in southeastern Alaska, near Wrangell. Several years ago some shipments of mineral water were made from a spring near Wrangell. A little graphite has been produced on Seward Peninsula. Some volcanic ash has been shipped from Kodiak during the last three years for use as an abrasive.

METAL MINING.

GENERAL FEATURES.

In 1914 about 32 per cent of the total gold production came from lode mines, the balance from placer mines. In 1913 31.6 per cent of the total gold output was credited to lode mines; in 1912 the amount so credited was 29 per cent of the total. In the following table the production of precious metals has been distributed as to sources:

Sources of gold, silver, and copper in Alaska, 1914, by kinds of ore.

	Total quantity.	Gold.		Silver.		Copper.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Tons.	*Fine ounces.*		*Fine ounces.*		*Pounds.*	
Siliceous ores	1,738,127	235,248.98	$4,863,028	28,254	$15,624	.....	.....
Copper ores	153,605	8,283.30	171,231	283,355	156,695	21,450,628	$2,852,934
Placers	.....	519,063.75	10,730,000	83,196	46,008	.....	.....
	1,891,732	762,596.03	15,764,259	394,805	218,327	21,450,628	2,852,934

[1] Martin, G. C., Johnson, B. L., and Grant, U. S., Geology and mineral resources of Kenai Peninsula, Alaska: U. S. Geol. Survey Bull. 587, pp. 107–110, 1915.

Alaska's auriferous lode mines produced during the year 235,249 fine ounces of gold, valued at $4,863,028, compared with 232,916 fine ounces, valued at $4,814,813, in 1913. These mines made an output of 28,254 fine ounces of silver, valued at $15,624, in 1914, and 30,897 ounces, valued at $18,662, in 1913.

Twenty-eight gold-lode mines, including several properties which made only small outputs, were operated the whole or a part of the year 1914 in Alaska—two less than in 1913. Work was also done on many gold prospects, some of which produced a little gold. Of the producing mines nine were in southeastern Alaska, eight on Prince William Sound, four in Kenai Peninsula, three in the Willow Creek district, and four in the Fairbanks district. It is estimated that these mines had an output of 1,738,127 tons of ore, compared with 1,614,506 tons in 1913. In 1913 the average value of the gold and silver contents for all the ores mined was $2.99 a ton; the average for 1914 was $2.79.

Six copper mines were operated in Alaska for a whole or a part of the year 1914, compared with seven in 1913. Of these two were in the Ketchikan district, two on Prince William Sound, and two in the Kotsina-Chitina district. The total production of copper in 1914 is estimated to have been 21,450,628 pounds, valued at $2,852,934, compared with 21,659,958 pounds, valued at $3,357,293, in 1913. About $171,231 worth of gold and $156,695 worth of silver were recovered from the copper ores. It is estimated that in 1914 about 153,605 tons of copper ore was mined, compared with 135,730 tons in 1913. The average copper content of the ore was about 6.98 per cent and the value of the gold and silver recovered about $2.04 to the ton.

It is estimated by the mine inspector for the Territory of Alaska that during the fiscal year ending June 30, 1914, 4,500 men were engaged in lode mining.[1] Though this is the fiscal and not the calendar year, it serves to indicate approximately the number of men employed in 1914.

The value of the placer gold produced in 1914 is estimated at $10,730,000; that of 1913 was $10,680,000. As compared with the previous year there was a decrease in the placer-gold output from the Fairbanks, Koyukuk, and Fortymile districts and an increase from the Ruby and Seward Peninsula districts, as well as from some of the smaller camps. It is estimated that about 730 placer mines were operated in 1914, but many for only a part of the season; the number was 700 in 1913. About 4,740 men were engaged in productive placer mining, most of them for only a small part of the

[1] Smith, S. S., Report of the mine inspector for the Territory of Alaska to the Secretary of the Interior for the fiscal year ended June 30, 1914, p. 10.

year. In addition there were probably 500 to 1,000 men engaged in prospecting and other nonproductive work relating to the placer-mining industry.

Two new localities where placer gold occurs were reported in 1914, both in the Tanana basin. One is on a stream tributary to the lower Healy River and, so far as now known, includes only a small area of auriferous gravels. The other is in the upper Tolovana basin, and here, according to reports of prospectors, the outlook for placer mining is rather encouraging.

In accordance with past practice, a table is given here to show approximately the total bulk of gravel mined annually in Alaska for several years and the value of the gold recovered per cubic yard. This table is based on certain assumptions which do not now admit of proof but which are supported by a large number of facts. Therefore, although the table is only approximately correct, it indicates the magnitude of the true figures.

Estimated total amount of gravel sluiced in Alaska placer mines and value per cubic yard of gold recovered, 1908–1914.

	Total quantity of gravel.	Value of gold recovered per cubic yard.		Total quantity gravel.	Value of gold recovered per cubic yard.
	Cubic yards.			*Cubic yards.*	
1908	4,275,000	$3.74	1912	7,050,000	$1.70
1909	4,413,000	3.66	1913	6,800,000	1.57
1910	4,036,000	2.97	1914	8,500,000	1.26
1911	5,790,000	2.17			

Forty-two gold dredges were operated for a whole or a part of the mining season in 1914. Of these, 39 were located on Seward Peninsula, 2 in the Iditarod district, and 1 in the Fairbanks district. It is estimated that these dredges handled 4,450,000 cubic yards and made a gold recovery of $2,350,000. The average gold content of the gravels mined is 50 cents to the cubic yard. In 1913, 35 gold dredges were operated and handled about 4,100,000 cubic yards, having a value of $2,200,000. Two of the gold dredges operating on Seward Peninsula in 1914 are on Anikovik River, in the York district, and were used to recover stream tin as well as gold. In addition to these, the dredge on Buck Creek was operated on a tin placer, as in previous years.

Some attempts at gold dredging were made in Alaska as early as 1900. This form of mining did not, however, reach a profitable stage until about 1903, when two small dredges were successfully operated on Seward Peninsula. In 1907 a dredge was installed in the Fortymile district, the first in the Alaska part of the Yukon basin. Up to the close of 1914 gold to the value of $10,100,894 had

been mined in Alaska by dredges. The growth of the gold-dredging industry is indicated by the following table:

Estimate of gold production from dredge mining in Alaska, 1903–1914.

Year.	Number of dredges operated.	Value of gold output.	Year.	Number of dredges operated.	Value of gold output.
1903	2	$20,000	1910	18	$800,000
1904	3	25,000	1911	27	1,500,000
1905	3	40,000	1912	38	2,200,000
1906	3	120,000	1913	36	2,200,000
1907	4	250,000	1914	42	2,350,000
1908	4	170,901			
1909	14	424,993			10,100,894

MINERAL FUELS.

In 1913 only one coal mine was operated in Alaska. This, the Wharf mine, located at Port Graham, on Cook Inlet, produced lignitic coal, which found a local market. In 1914 this mine was closed and not a single commercial coal mine was operated in the Territory. There was, however, a little mining of lignitic coal at several localities for individual use. The following table shows the coal consumption of Alaska from 1899 to 1914:

Coal consumption of Alaska, by sources, 1899 to 1914, in short tons.

Year.	Imported from States, chiefly from Washington.		Produced in Alaska, chiefly subbituminous and lignite.[a]	Total domestic, chiefly from Washington.[a]	Total foreign coal, chiefly bituminous, from British Columbia.[b]	Total coal consumed.
	Bituminous.	Anthracite.				
1899	[c] 10,000	.....	[c] 1,200	11,200	50,120	61,320
1900	15,048	.....	[c] 1,200	16,248	56,623	72,871
1901	[c] 24,000	.....	[c] 1,300	25,300	77,674	102,974
1902	[c] 40,000	.....	2,212	42,212	68,363	110,575
1903	64,625	1	1,447	66,073	60,605	126,678
1904	36,689	.....	1,694	38,383	76,815	115,198
1905	67,707	6	3,774	71,487	72,567	144,054
1906	68,960	533	5,541	75,034	47,590	122,624
1907	45,130	1,116	10,139	56,385	88,596	144,981
1908	23,402	491	3,107	27,000	72,831	99,831
1909	33,112	.....	2,800	35,912	74,316	110,228
1910	32,138	.....	1,000	33,138	73,904	107,042
1911	32,255	.....	900	33,155	88,573	121,728
1912	27,767	.....	355	28,122	59,804	87,926
1913	61,666	.....	[c] 2,300	63,966	60,600	124,566
1914	37,062	.....	.....	37,062	21,882	58,944
	619,561	2,147	38,969	660,677	1,050,863	1,711,540

[a] By calendar years. [b] By fiscal years ending June 30. [c] Estimated.

The decline in coal consumption is more than made up by the increase in consumption of crude petroleum and gasoline. (See p. 39.) Most of the coal shipped to Alaska is used along the Pacific seaboard. In 1914 a total of 2,087 tons of domestic coal and 446 tons of foreign

coal was received at Nome.[1] This represents the total coal consumption of Seward Peninsula, except for a little lignite mined at Chicago Creek, in the Fairhaven district. Fifty tons of coal were received at the port of St. Michael,[2] largely for local use, but including a little blacksmith coal shipped up the Yukon to the mining camps. Practically all the rest of the coal, amounting to some 36,807 tons, was used in southeastern Alaska, on Prince William Sound, in the lower Copper River region, and at other points along the Pacific seaboard. Some is shipped to canneries on Bristol Bay, to the Pribilof Islands, and for the use of local steamers to Unalaska. This tonnage does not include the consumption by steamers plying between Alaska and Puget Sound ports. It should be noted, however, that many of these steamers are oil burners.

Steaming tests have now been made by the Navy Department of coal from one or two beds in each of the high-grade fields—the Bering River and Matanuska. The results of the tests of Bering River coal have been published in complete form, and as the report may not be available to all who receive this volume the following data are extracted from it:[3]

The test was made on about 855 tons of coal mined under the direction of R. Y. Williams, a mining engineer detailed from the United States Bureau of Mines. The coal was taken from the Tenino claim of the so-called Cunningham group. Of the total coal mined, 674 tons was taken from one opening, and most of the coal appears to have been taken from a single bed. Mr. Williams estimates the cost of mining this coal at $3.05 a ton, including all overhead charges.

General conclusions in regard to the occurrence of the coal are summarized as follows:[4]

> As the actual detailed examination of this region proceeded in connection with the extraction of the large sample of coal for subsequent ship test it was found that all of these beds upon which excavations were made proved to be lenticular or otherwise irregular in shape, and the coal proved to vary from high-grade and fairly lumpy coal at certain places to a crushed coal, which at some points was high-grade and at other points a decidedly low-grade material.

The conclusions of the Navy Department in regard to the steaming tests made on this coal are summarized as follows:[5]

> It is with regret, then, that the department reports that the recent tests show conclusively that Bering River coal, mined from selected veins in one of the most promising portions of the field, is entirely unsuitable for naval use. Formerly the defect that gave the greatest concern was the general crushed condition of the coal, from which a large percentage of slack might be expected.

[1] Data received through courtesy of deputy collector of customs at Nome.
[2] Data received through courtesy of deputy collector of customs at St. Michael.
[3] Report on coal in Alaska for use in United States Navy: 63d Cong., 2d sess., H. Doc. 876, 1914.
[4] Idem, p. 7.
[5] Idem, pp. 122–128.

An adequate percentage of lump was found, however, although it developed that much if not all of the slack must be washed, for it appears impossible for the miner to avoid knocking down the black shale bands with the coal, and the separation of these impurities from the coal is not practicable in any other way than by washing, which increases the cost of mining while not overcoming the inherent objections to slack coal.

The coal, however, failed on account of its property of forming large, tenacious clinker—probably the most serious defect that can be developed by a coal for marine use. Whether or not a nonclinkering coal of good chemical and physical qualities exists in the field is an unsolved problem. The Bering River sample tried by the *Nebraska* in 1908 did not clinker at the low rate of combustion and consequent low furnace temperatures pertaining during that inconclusive trial. However, neither did the Bering River coal recently tested clinker under natural draft. Coal from that part of the field from which the *Nebraska* sample was mined is generally slack and apparently not in this respect equal in physical qualities to the all-round satisfactory grade which it is hoped may be found.

It thus appears that in a field like the Bering River, where in a comparatively small area anthracite, semianthracite, and semibituminous coals are found, and moreover, where the measures have been so extensively disturbed, lack of uniformity in grade may be expected. It seems, therefore, that if coal suitable for naval use exists, it can not be spotted by chemical or physical excellence, but must be searched out by the laborious and expensive but conclusive methods of trial under service conditions.

The clinkering of coal is a subject on which but little of value is known from analysis. It varies with the type of grate, rate of combustion, depth of fire, and draft, so that the only positive guide as to its existence, nonexistence, or extent is a trial under the actual conditions under which the coal will be used. For this reason the department would not regard a field test for clinkering—analyzing, taking temperatures of ash fusibility, tests in small grates or boilers—as information of any positive value. This procedure would be expensive and the results probably misleading. Now that the Alaskan railroads will be built, and a line extended into the Bering River fields, and the coal fields probably opened to leasing, the further test of coal from these fields for naval use should be resumed as soon as possible after the completion of the road, and after general development has set in in the coal fields, by the trial of large samples (cargoes) from various seams. In this manner only, in the department's opinion, can the existence of a satisfactory coal for naval use be ascertained.

In conclusion, the failure on test of the excellent Bering River sample at the engineering experiment station from severe and unusual clinkering—a sample better in all respects than the Pocahontas used in comparative test—obliges the department to regard and so report the Bering River field to be unavailable as a source of coal for the Navy until extensive development definitely locates coal not possessing the serious objection found in the sample tested by the department.

This must not be regarded as a conclusive test of the quality of coal in the entire Bering River field. Martin,[1] who surveyed the field in detail in the seasons of 1904 to 1906, has shown that there

[1] Martin, G. C., Geology and mineral resources of the Controller Bay region, Alaska: U. S. Geol. Survey Bull. 335, 1908.

are many beds in the field and much variation in the quality of the coal in different parts of the coal-bearing area. Therefore, while the test recorded above shows that the beds mined do not carry the high-grade coal demanded for naval use, yet this by no means condemns the entire field. There can be no doubt that the Bering River field includes a large amount of steaming coal in beds that can be mined.

In 1913 about 1,100 tons of coal was mined at Chickaloon, in the Matanuska field, under the direction of the United States Bureau of Mines. This was presumably taken from one or two beds. This coal was sledded to the coast during the winter and subjected to a steaming test by the Navy Department. The complete report on this examination and test has not been published, so that no data are available on the cost of mining, underground conditions, etc. The coal field has, however, been reported upon in detail by Martin and Katz.[1]

The test of the coal showed it to be satisfactory for naval use, as shown by the following report:[2]

NAVY DEPARTMENT, SUMMARY REPORT ON TEST OF MATANUSKA COAL.

Port test, seven days.—All coal, ash, and clinker were weighed, one boiler was used, forced draft was necessary on two days. Run of mine coal was used for five days, slack for one day, and lump coal for one day. There were no casualties. Coal burned very freely. Firing was very good, the analyses of flue gases giving rarely below 9 per cent of CO_2. There was little clinker, but the ash was several per cent higher than with the Pocahontas coal. Draft was good and coal burned with bright-yellowish flame. Coal coked very nicely; the coke was friable and very easily worked by the firemen. Fires 6 inches to 8 inches thick were carried most of the time, although occasionally they were heavier. The ash fused into clinker on the grate bars, generally about 2 inches thick, medium weight, porous, a little tough and hard while hot but friable when cold. The clinker had a little ash mixed throughout the mass. It stuck a little to the bridge wall, but not seriously. The soot deposit was about 25 per cent more than the Pocahontas coal. The soot was a little different from that of the Pocahontas, as the granules appeared as minute fused grains. The load during this week of test would ordinarily have required two boilers burning Pocahontas coal.

Four-hour forced draft.—Fires thin; dampers partly closed. Fires burned brightly; work of firing very easy on account of ease of breaking up the coke. Furnaces one mass of yellowish flame. Not an excessive amount of ash formed. The men, on being questioned, all said it was the easiest 20-knot run they had ever made.

Twenty-four hour 15-knot test.—Started with 12 boilers, but necessary to cut out four boilers to get the highest efficiency. Coal burned with greatest ease, forming a very easily worked coke, not an excessive amount of ash or clinker,

[1] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley, Alaska: U. S. Geol. Survey Bull. 500, 1912.

[2] Alaska railroads, statement of Hon. Franklin K. Lane, Secretary of Interior. Monday, February 1, 1915: Sundry civil bill, 1916, supplement to hearings before subcommittee of House Committee on Appropriations, pp. 15–17.

and in general appeared easier to handle than Pocahontas coal. CO_2 analysis generally high, over 9 per cent. Fires, carried 6 inches to 8 inches thick, were always glowing, ash pans bright, and the furnaces a mass of yellowish incandescent flame. Coal burned like pine knots. The amount of clinker was not excessive, was more or less easy to work, and very friable when cold. Fires were noticeably hot. Amount of soot made was a little higher than is usually made by good Pocahontas coal, about 10 per cent more.

Ten-knot test.—Started with six boilers, but it was found necessary to cut out two boilers to give greatest efficiency. This power was more than ample, as at times there were four evaporators in use. Fires were very easily worked; the coke broke up easily; clinker was not very hard; bright, level fires from 6 inches to 8 inches thick and sometimes thicker were carried, and CO_2 was generally high.

General remarks.—There was very little foreign matter. The slack appeared to burn better than the lump. No evidences of gases being given off from the coal during the test. The noticeable characteristic of this coal is friability. Lumps pulverize very easily.

Port test of seven days.

Coal.	Total tons.	Water evaporated.	Coal per gallon.	Ash.	Efficiency.
		Gallons.	*Pounds.*	*Per cent.*	*Per cent.*
Pocahontas	94.291	248,610	1.168	11.04	100
Bering River	136.391	247,783	.811	36.6	69.4
Matanuska	116.185	305,446	1.177	15.8	100.3

Four-hour forced draft, speed 20 knots.

Coal.	Total tons.	Ash.	Smoke by scale.	Knots per ton.	Indicated horsepower.	Pounds per indicated horsepower.	Steaming radius.	Average efficiency.
		Per cent.						*Per cent.*
Pocahontas	79.1	8.8	2.4	1.02	20,820.3	2.09	2,367.8	100
Bering River	127.3	33.8	1.5	.60	13,992.3	5.32	.....	.....
Matanuska	85.484	18.67	2.8	.93	19,929.15	2.32	2,002.2	91

15 knots, 24-hour test.

Pocahontas	153.155	7.6	1.25	2.38	7,083	2.01	4,781	100
Bering River	160.3	35.0	.60	1.09	7,600	4.98	2,372	43
Matanuska	157.212	14.59	1.99	2.29	6,142.37	2.15	4,796.3	96

10 knots, 48-hour test.

Pocahontas	137.325	10.5	1.18	3.515	2,134	3.08	7,077	100
Matanuska	118.582	15.67	1.86	3.37	2,686.527	3.09	7,160.6	98

The board found that this sample of Matanuska coal tested is suitable in every respect for use in the naval service.

DEPARTMENT OF THE INTERIOR,
BUREAU OF MINES,
Experiment Station, Pittsburgh, Pa., December 17, 1914.

Subject: Report on tests of Matanuska coal on U. S. S. *Maryland.*

The Director: The following is Mr. Flagg's report upon the tests of Matanuska coal aboard the U. S. S. *Maryland:*

Inspection and loading.

Upon the *Maryland's* arrival at Bremerton a visit was made to the coal dock, where some 7,700 sacks of the coal were stored under cover. On account of the receipt of a letter from the Bureau of Steam Engineering stating that preliminary tests at Annapolis indicated high ash content and instructing that the necessary preparation be given the coal, a preliminary inspection was made to gain some idea as to the quality of the coal. Rough determinations of the ash contents of the different-sized parts of a sample taken from six bags at random failed to show any excessive percentages of ash, so the coal was loaded onto the lighters and placed in the ship's bunkers.

During the loading of the lighters a shovelful of coal was taken from every fifth bag and retained for a sample. This sample (of about 3 tons) was worked over and one can retained. From the same sample a portion (about 800 pounds) was taken for a sizing test. The percentages of the different sizes, the analyses of the samples of the several sizes, and the analysis of the general sample are given in attached sheets.

Seven-day port test.

The port test was begun as soon as one lighter of coal had been taken on. The load during part of the test period was heavy but was carried throughout the test on one boiler. Fires were cleaned every 12 hours, by which time about 2 inches of clinker had formed. The clinker was medium weight, rather porous, and dark colored, with small pieces of light-gray ash mixed in with the fused portion. The clinker stuck some to the bridge wall, but not enough to cause serious trouble, and did not stick to the grates at all. In the furnace the clinker could be broken fairly easily; when cold it was brittle and easily broken.

During the port test the gas analyses showed 10 to 12 per cent CO_2 with probably 0.3 to 0.4 per cent CO. The effort was to carry fires 7 to 8 inches thick, but they were heavier much of the time, thus accounting in one way for the presence of CO.

The soot formed was comparatively free from tarry matter and hence did not adhere to the tubes as much as does that from Pocahontas coal, although the amount of soot formed by the Matanuska coal was more than with Pocahontas.

The figures for the evaporation, on account of the difficulties incident to the measurement of the feed water, can only be considered approximate at best. The figures obtained during the port test showed an evaporation equal to or a little better than was obtained during the test with Pocahontas coal made by the *Maryland* in 1913.

On the last two days of the port test the use of screened coal was tried. The coal for this purpose was screened on the lighter alongside the dock. One day all of the coal remaining on a 4-mesh screen was used, and on the other that which passed through the screen. The only trouble experienced with the finer coal was that the natural draft was not quite strong enough to maintain the required rate of combustion at all times.

20-knot test.

The excellent steaming properties of this coal were plainly shown in this test. For a time it looked as if it would be possible to make the turns for 20 knots without putting on the blowers, but it was not done. With about three-fourths inch pressure of air in the firerooms, however, there was an abundance of steam, and steam could be raised to the popping-off pressure at any minute. This condition obtained throughout the 4-hour test, and at its close the fires were still in excellent steaming condition.

15-knot test.

For the 15-knot test twelve boilers were lit up, but soon after the test was started two of these were put out and later a third. During the remainder of the test the turns were kept up most of the time with eight boilers working and the ninth banked. Difficulty in maintaining the desired steam pressure with the eight boilers was experienced only at times of cleaning the fires, and then only when the fires were cleaned too soon after each other. For cruising at this speed it has been the practice to use ten boilers with eastern coal.

10-knot test.

Six boilers were lit for this run, but one was banked almost at the start of the test, and later it was cut out. About 2½ hours after the test started a second boiler was banked, and this was cut out when the test had been in progress 9 hours. During the remainder of the test four boilers only were used, these furnishing plenty of steam to make the proper number of turns and keep the regular auxiliaries going. For this speed the practice has been to use six boilers with Pocahontas coal. So far as is known the *Maryland* has never before made turns for 10 knots with only four boilers in use.

General.

The coal as stored on the dock was dry, but was wet on the lighters after they were placed alongside the ship. Neither on the dock nor in the bunkers was any tendency to heating noticed. The coal was almost entirely free from lumps, but for the most part was not objectionably fine.

It is a fairly friable coal, has moderate coking tendency, and is excellent for steaming purposes. The volatile matter appears to be fairly easily driven off, but is not difficult to burn.

From the standpoint of smokelessness the coal is also very desirable. Under natural draft the stack observations ranged between No. 0 and No. 3 (Rengelmann chart), averaging somewhat above No. 2. Under forced draft during the 4-hour run the smoke averaged about the same, but showed less of the heavier smoke. The smoke is somewhat less in density than that from Pocahontas and it is not as black.

Both officers and men cooperated heartily with the Bureau's engineer throughout the test, and this cooperation was one factor contributing to the success of the tests.

Very truly, yours,

(Signed) O. P. Hood,
Chief Mechanical Engineer.

No new discoveries of coal in Alaska were reported in 1914, with the exception of some lignite in the Ruby district. The extent of

these deposits and their availability as fuel have not been determined. By far the most important event of the year with reference to the Alaska coal fields was the passage of a coal-leasing law. This act is as follows:

[PUBLIC—No. 216—63D CONGRESS.]

[H. R. 14233.]

An Act To provide for the leasing of coal lands in the Territory of Alaska, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Interior be, and hereby is, authorized and directed to survey the lands of the United States in the Territory of Alaska known to be valuable for their deposits of coal, preference to be given first in favor of surveying lands within those areas commonly known as the Bering River, Matanuska, and Nenana coal fields, and thereafter to such areas or coal fields as lie tributary to established settlements or existing or proposed rail or water transportation lines: *Provided*, That such surveys shall be executed in accordance with existing laws and rules and regulations governing the survey of public lands. There is hereby appropriated, out of any money in the Treasury not otherwise appropriated, the sum of $100,000 for the purpose of making the surveys herein provided for, to continue available until expended: *Provided*, That any surveys heretofore made under the authority or by the approval of the Department of the Interior may be adopted and used for the purposes of this Act.

SEC. 2. That the President of the United States shall designate and reserve from use, location, sale, lease, or disposition not exceeding five thousand one hundred and twenty acres of coal-bearing land in the Bering River field and not exceeding seven thousand six hundred and eighty acres of coal-bearing land in the Matanuska field, and not to exceed one-half of the other coal lands in Alaska: *Provided*, That the coal deposits in such reserved areas may be mined under the direction of the President when, in his opinion, the mining of such coal in such reserved areas, under the direction of the President, becomes necessary, by reason of an insufficient supply of coal at a reasonable price for the requirements of Government works, construction and operation of Government railroads, for the Navy, for national protection, or for relief from monopoly or oppressive conditions.

SEC. 3. That the unreserved coal lands and coal deposits shall be divided by the Secretary of the Interior into leasing blocks or tracts of forty acres each, or multiples thereof, and in such form as in the opinion of the Secretary will permit the most economical mining of the coal in such blocks, but in no case exceeding two thousand five hundred and sixty acres in any one leasing block or tract; and thereafter, the Secretary shall offer such blocks or tracts and the coal, lignite, and associated minerals therein for leasing, and may award leases thereof through advertisement, competitive bidding, or such other methods as he may by general regulations adopt, to any person above the age of twenty-one years who is a citizen of the United States, or to any association of such persons, or to any corporation or municipality organized under the laws of the United States or of any State or Territory thereof: *Provided*, That a majority of the stock of such corporation shall at all times be owned and held by citizens of the United States: *And provided further*, That no railroad or common carrier shall be permitted to take or acquire through lease or permit under this Act

any coal or coal lands in excess of such area or quantity as may be required and used solely for its own use, and such limitation of use shall be expressed in all leases or permits issued to railroads or common carriers hereunder: *And provided further*, That any person, association, or corporation qualified to become a lessee under this Act and owning any pending claim under the public-lands laws to any coal lands in Alaska may, within one year from the passage of this Act, enter into an arrangement with the Secretary of the Interior by which such claim shall be fully relinquished to the United States; and if in the judgment of the Secretary of the Interior, the circumstances connected with such claim justify so doing, the moneys paid by the claimant or claimants to the United States on account of such claim shall, by direction of the Secretary of the Interior, be returned and paid over to such person, association, or corporation as a consideration for such relinquishment.

All claims of existing rights to any of such lands in which final proof has been submitted and which are now pending before the Commissioner of the General Land Office or the Secretary of the Interior for decision shall be adjudicated within one year from the passage of this Act.

SEC. 4. That a person, association, or corporation holding a lease of coal lands under this Act may, with the approval of the Secretary of the Interior and through the same procedure and upon the same terms and conditions as in the case of an original lease under this Act, secure a further or new lease covering additional lands contiguous to those embraced in the original lease, but in no event shall the total area embraced in such original and new leases exceed in the aggregate two thousand five hundred and sixty acres.

That upon satisfactory showing by any lessee to the Secretary of the Interior that all of the workable deposits of coal within a tract covered by his or its lease will be exhausted, worked out, or removed within three years thereafter, the Secretary of the Interior may, within his discretion, lease to such lessee an additional tract of land or coal deposits, which, including the coal area remaining in the original lease, shall not exceed two thousand five hundred and sixty acres, through the same procedure and under the same competitive conditions as in case of an original lease.

SEC. 5. That, subject to the approval of the Secretary of the Interior, lessees holding under leases small blocks or areas may consolidate their said leases or holdings so as to include in a single holding not to exceed two thousand five hundred and sixty acres of contiguous lands.

SEC. 6. That each lease shall be for such leasing block or tract of land as may be offered or applied for, not exceeding in area two thousand five hundred and sixty acres of land, to be described by the subdivisions of the survey, and no person, association, or corporation, except as hereinafter provided, shall be permitted to take or hold any interest as a stockholder or otherwise in more than one such lease under this Act, and any interest held in violation of this proviso shall be forfeited to the United States by appropriate proceedings instituted by the Attorney General for that purpose in any court of competent jurisdiction, except that any such ownership and interest hereby forbidden which may be acquired by descent, will, judgment or decree may be held for two years, and not longer, after its acquisition.

SEC. 7. That any person who shall purchase, acquire, or hold any interest in two or more such leases, except as herein provided, or who shall knowingly purchase, acquire, or hold any stock in a corporation having an interest in two or more such leases, or who shall knowingly sell or transfer to one disqualified to purchase, or except as in this Act specifically provided, disqualified to acquire, any such interest, shall be deemed guilty of a felony, and upon conviction shall be punished by imprisonment for not more than three years and

by a fine not exceeding $1,000: *Provided*, That any such ownership and interest hereby forbidden which may be acquired by descent, will, judgment, or decree may be held two years after its acquisition and not longer, and in case of minority or other disability such time as the court may decree.

SEC. 8. That any director, trustee, officer, or agent, of any corporation holding any interest in such a lease who shall, on behalf of such corporation, act in the purchase of any interest in another lease, or who shall knowingly act on behalf of such corporation in the sale or transfer of any such interest in any lease held by such corporation to any corporation or individual holding any interest in any such a lease, except as herein provided, shall be guilty of a felony and shall be subject to imprisonment for a term of not exceeding three years and a fine of not exceeding $1,000.

SEC. 8a. If any of the lands or deposits leased under the provisions of this Act shall be subleased, trusteed, possessed, or controlled by any device permanently, temporarily, directly, indirectly, tacitly, or in any manner whatsoever, so that they form part of or are in anywise controlled by any combination in the form of an unlawful trust, with consent of lessee, or form the subject of any contract or conspiracy in restraint of trade in the mining or selling of coal, entered into by the lessee, or of any holding of such lands by any individual, partnership, association, corporation, or control, in excess of two thousand five hundred and sixty acres in the Territory of Alaska, the lease thereof shall be forfeited by appropriate court proceedings.

SEC. 9. That for the privilege of mining and extracting and disposing of the coal in the lands covered by his lease the lessee shall pay to the United States such royalties as may be specified in the lease, which shall not be less than two cents per ton, due and payable at the end of each month succeeding that of the shipment of the coal from the mine, and an annual rental, payable at the beginning of each year, on the lands covered by such lease, at the rate of twenty-five cents per acre for the first year thereafter, fifty cents per acre for the second, third, fourth, and fifth years, and $1 per acre for each and every year thereafter during the continuance of the lease, except that such rental for any year shall be credited against the royalties as they accrue for that year. Leases may be for periods of not more than fifty years each, subject to renewal, on such terms and conditions as may be authorized by law at the time of such renewal. All net profits from operation of Government mines, and all royalties and rentals under leases as herein provided, shall be deposited in the Treasury of the United States in a separate and distinct fund to be applied to the reimbursement of the Government of the United States on account of any expenditures made in the construction of railroads in Alaska, and the excess shall be deposited in the fund known as The Alaska Fund, established by the Act of Congress of January twenty-seventh, nineteen hundred and five, to be expended as provided in said last-mentioned Act.

SEC. 10. That in order to provide for the supply of strictly local and domestic needs for fuel the Secretary of the Interior may, under such rules and regulations as he may prescribe in advance, issue to any applicant qualified under section three of this Act a limited license or permit granting the right to prospect for, mine, and dispose of coal belonging to the United States on specified tracts not to exceed ten acres to any one person or association of persons in any one coal field for a period of not exceeding ten years, on such conditions not inconsistent with this Act as in his opinion will safeguard the public interest, without payment of royalty for the coal mined or for the land occupied: *Provided*, That the acquisition of holding of a lease under the preceding sections of this Act shall be no bar to the acquisition, holding, or operating under the

limited license in this section permitted. And the holding of such a license shall be no bar to the acquisition or holding of such a lease or interest therein.

SEC. 11. That any lease, entry, location, occupation, or use permitted under this Act shall reserve to the Government of the United States the right to grant or use such easements in, over, through, or upon the land leased, entered, located, occupied, or used as may be necessary or appropriate to the working of the same or other coal lands by or under authority of the Government and for other purposes: *Provided*, That said Secretary, in his discretion, in making any lease under this Act, may reserve to the United States the right to lease, sell, or otherwise dispose of the surface of the lands embraced within such lease under existing law or laws hereafter enacted in so far as said surface is not necessary for use by the lessee in extracting and removing the deposits of coal therein. If such reservation is made, it shall be so determined before the offering of such lease.

That the said Secretary during the life of the lease is authorized to issue such permits for easements herein provided to be reserved, and to permit the use of such other public lands in the Territory of Alaska as may be necessary for the construction and maintenance of coal washeries or other works incident to the mining or treatment of coal, which lands may be occupied and used jointly or severally by lessees or permittees, as may be determined by said Secretary.

SEC. 12. That no lease issued under authority of this Act shall be assigned or sublet except with the consent of the Secretary of the Interior. Each lease shall contain provisions for the purpose of insuring the exercise of reasonable diligence, skill, and care in the operation of said property, and for the safety and welfare of the miners and for the prevention of undue waste, including a restriction of the workday to not exceeding eight hours in any one day for underground workers except in cases of emergency; provisions securing the workers complete freedom of purchase, requiring the payment of wages at least twice a month in lawful money of the United States, and providing proper rules and regulations to secure fair and just weighing or measurement of the coal mined by each miner, and such other provisions as are needed for the protection of the interests of the United States, for the prevention of monopoly, and for the safeguarding of the public welfare.

SEC. 13. That the possession of any lessee of the land or coal deposits leased under this act for all purposes involving adverse claims to the leased property shall be deemed the possession of the United States, and for such purpose the lessee shall occupy the same relation to the property leased as if operated directly by the United States.

SEC. 14. That any such lease may be forfeited and canceled by appropriate proceeding in a court of competent jurisdiction whenever the lessee fails to comply with any provision of the lease or of general regulations promulgated under this Act; and the lease may provide for the enforcement of other appropriate remedies for breach of specified conditions thereof.

SEC. 15. That on and after the approval of this Act no lands in Alaska containing deposits of coal withdrawn from entry or sale shall be disposed of or acquired in any manner except as provided in this Act: *Provided*, That the passage of this Act shall not affect any proceeding now pending in the Department of the Interior, and any such proceeding may be carried to a final determination in said department notwithstanding the passage hereof: *Provided further*, That no lease shall be made, under the provisions hereof, of any land, a claim for which is pending in the Department of the Interior at the date of the passage of this Act, until and unless such claim is finally disposed of by the department adversely to the claimant.

SEC. 16. That all statements, representations, or reports required, unless otherwise specified, by the Secretary of the Interior under this Act shall be upon oath and in such form and upon such blanks as the Secretary of the Interior may require, and any person making false oath, representation, or report shall be subject to punishment as for perjury.

SEC. 17. That the Secretary of the Interior is authorized to prescribe the necessary and proper rules and regulations and to do any and all things necessary to carry out and accomplish the purposes of this Act.

SEC. 18. That all Acts and parts of Acts in conflict herewith are hereby repealed.

Approved, October 20, 1914.

The form of lease and the regulations under the general provisions of this act have not yet been announced. The following form and regulations, however, have been issued by the Commissioner of the General Land Office to meet the clause providing for short-term permits to mine coal for local use on tracts not exceeding 10 acres:

Application for permit to mine coal in Alaska under section 10 of the act of October 20, 1914 (Public 216).

----------, 191__

The Commissioner of the General Land Office, Washington, D. C.

SIR: The undersigned, ----------
(Name of applicant.)

---

of ----------, hereby appl for a permit to prospect for, mine, and
(Post-office address.)

remove coal from the following-described land: ----------
(Describe the land by legal subdi-

---

vision if surveyed and by metes and bounds with reference to some permanent natural

---

landmark if unsurveyed.)

---

containing approximately ------ acres, situated within the ------ land district,

------ miles ---------- of ----------, Alaska, and in support
(Direction.)

of this application make the following representation as to qualifications to

receive a permit: ----------
(Citizenship of applicant or applicants must here be shown. If the

---

applicant is a municipality or corporation, it must be shown under what laws it is

---

organized; and if the latter, it must also be shown whether a majority of its stock is

---

owned and held by citizens of the United States.)

The applicant further represent that _____ ha not, within two
(He, they, or it.)

years last past, applied for or received a permit to mine coal under the provisions of section 10 of the act of October 20, 1914, in the coal field in which the land described in this application is situated, _____
(State exceptions here, if any.)

_____

and that the coal herein applied for is to be mined for the purpose of supplying the following demands, for which approximately _____ tons are required annually: _____
(Here itemize the various uses to which the coal is to be applied,

_____
stating the number of tons necessary for each use.)

_____

It is further represented that the boundaries of the tract described in this application have been plainly marked by substantial monuments and that a proper notice describing the land and showing the intention of the applicant to apply for a free permit to mine coal therefrom has been posted in a conspicuous place upon the land.

On consideration that a permit be granted, the applicant hereby agree :

1. To exercise reasonable diligence, precaution, and skill in the operation of the mine, with a view to the prevention of injury to workmen, waste of coal, damage to Government property, and to comply substantially with the instructions and the rules and regulations printed on the back of this application.

2. To charge only such prices for coal sold to others as represent a fair return for the labor expended and reasonable earning value to which the investment in the enterprise is entitled, without including any charge for the coal itself.

3. Not to mine or dispose of, either directly or indirectly, any coal from the area covered by said permit for export or any purpose other than "strictly local and domestic needs for fuel."

4. To leave the premises in good condition upon the termination of the permit, with all mine props and timbers in the mine intact and with the underground workings free from refuse and in condition for continued mining operations.

Signature of applicant _____

The foregoing application was signed by _____

_____,

of _____, the applicant therein, in the presence of the undersigned, who, at _____ request and in _____ presence
(His or their.) (His or their.)

and in the presence of each other, have subscribed our names as witnesses to the execution thereof.

Dated this ____ day of _____, 19 , at _____, Territory of Alaska.

Name _____ Residence _____

Name _____ Residence _____

Circular No. 370.—Regulations governing the issuance of permits for the free use of coal in the unreserved public lands in Alaska.

DEPARTMENT OF THE INTERIOR,
GENERAL LAND OFFICE,
Washington, December 30, 1914.

Registers and receivers of the United States land offices at Fairbanks, Juneau, and Nome, Alaska:

Section 10 of the act of October 20, 1914 (Public 216), provides:

"That in order to provide for the supply of strictly local and domestic needs for fuel the Secretary of the Interior may, under such rules and regulations as he may prescribe in advance, issue to any applicant qualified under section three of this act a limited license or permit granting the right to prospect for, mine, and dispose of, coal belonging to the United States on specified tracts not to exceed ten acres to any one person or association of persons in any one coal field for a period not exceeding ten years, on such conditions not inconsistent with this act as in his opinion will safeguard the public interest without payment of royalty for the coal mined or for the land occupied: *Provided*, That the acquisition of holding of a lease under the preceding sections of this act shall be no bar to the acquisition, holding, or operating under the limited license in this section permitted. And the holding of such license shall be no bar to the acquisition or holding of such a lease or interest therein."

Owing to the legal embarrassment occasioned by existing claims and there being no settlements or local industries in or adjacent to the Bering River or Matanuska coal fields, these regulations and the permits provided for shall not at present apply to coal deposits in those fields.

Qualifications.—Under the terms of the act, expressed in section 3 thereof, only citizens of the United States above the age of 21 years, associations of such citizens, corporations, and municipalities organized under the laws of the United States or of any State or Territory thereof, provided the majority of the stock of such corporations shall at all times be owned and held by citizens of the United States, are eligible to receive a permit to prospect for and mine coal from the unreserved public lands in Alaska.

Who may mine coal for sale.—All permittees may mine coal for sale except railroads and common carriers, who by the terms of section 3 of the act are restricted to the acquirement of only such an amount of coal as may be required and used for their own consumption.

Duration of permits.—Permits will be granted for two years, beginning at date of filing if filed in person or by attorney, or date of mailing if sent by registered letter, subject to the approval of the Commissioner of the General Land Office, and upon application and satisfactory showing as to the necessity therefor may be extended by the commissioner for a longer period, subject to such conditions necessary for the protection of the public interest as may be imposed prior to or at the time of the extension. Misrepresentation, carelessness, waste, injury to property, the charge of unreasonable prices for coal, or material violation of such rules and regulations governing operation as shall have been prescribed in advance of the issuance of a permit will be deemed sufficient cause for revocation.

Limitation of area.—The act limits the area to be covered in any one permit to 10 acres. It is not to be inferred from this, however, that the permits granted thereunder shall necessarily cover that area. The ground covered by a permit must be square in form and should be limited to an area reasonably sufficient to supply the quantity of coal needed.

Scope of permit.—Permits issued under section 10 of the act of October 20, 1914, grant only a license to prospect for, mine, and remove coal free of charge from the unreserved public coal lands in Alaska, and do not authorize the mining of any other form of mineral deposit nor the cutting or removal of timber.

How to proceed to obtain a permit.—The application should be duly executed on Form 4—020, and the same should either be transmitted by registered mail to or filed in person with the register and receiver of the United States land office of the district in which the land is situated. Prior to the execution of the application the applicant must have gone upon the land, plainly marked the boundaries thereof by substantial monuments, and posted a notice setting forth his intention of mining coal therefrom. The application must contain the statement that these requirements have been complied with, and the description of the land as given in the application must correspond with the description as marked on the ground. The permit, if granted, should be recorded with the local mining district recorder if the land is situated within an organized mining district.

When coal may be mined before issuance of a permit.—In view of the fact that by reason of long distances and limited means of transportation many applicants may be unable to appear in person at the United States land office to file their applications, it has been deemed advisable to allow such applicants the privilege of mining coal as soon as their applications have been duly executed and sent by registered mail to the proper United States land office. Should an application be rejected, upon receipt of notice thereof all privileges under this paragraph terminate, and the applicant must cease mining the coal.

Action by register.—The register will keep a proper record of all applications received and all actions taken thereon in a book provided for that purpose. If there appear no reason why the application should not be allowed, the register will issue a permit on the form provided for that purpose. Should any objection appear either as to the qualifications of the applicant or applicants, or in the substance or sufficiency of the application, the register may reject the application or suspend it for correction or supplemental showing under the usual rules of procedure, subject to appeal to the Commissioner of the General Land Office. Upon the issuance of a permit the register will promptly forward to the Commissioner of the General Land Office, by special letter, the original application and a copy of the permit, and transmit copies thereof to the chief of the Alaskan field division and to the local representative of the United States Bureau of Mines, for their information and use in the event that it should be found necessary or advisable to make investigations or inspections.

Note.—These regulations are intended merely as a temporary arrangement to meet immediate necessities, as authorized by section 10 of the act of October 20, 1914, and are not to be construed as applying to the leasing of public coal lands in Alaska provided in other sections of the act. Full regulations governing the matter of leasing will be issued as soon as practicable.

Very respectfully,

CLAY TALLMAN,
Commissioner.

Approved:
FRANKLIN K. LANE,
Secretary.

The Alaska oil lands were withdrawn from entry in 1906, and only claims located previous to that date are subject to entry. Patents

have been granted to a few claims near Katalla, where some oil has been produced for several years. A small refinery located near Katalla supplies gasoline to a local market. Except for this, there was no development of Alaska oil fields. Assessment work has, however, been continued on some unpatented oil claims.

As already noted, the shipment of petroleum products to Alaska has steadily increased for a number of years. Petroleum has rapidly supplanted coal as a source of power in the Pacific coast region of Alaska and on Seward Peninsula. The shipments of petroleum to Alaska during the past decade are shown in the following table:

Shipments of petroleum products to Alaska from other parts of the United States, 1905–1914.

Year.	Oil used for fuel, including crude oil, gas oil, residuum, etc.	Gasoline, including all lighter products of distillation.	Illuminating oil.	Lubricating oil.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*
1905	2,715,974	713,496	627,391	83,319
1906	2,688,940	580,978	568,033	83,992
1907	9,104,300	636,881	510,145	100,145
1908	11,891,375	939,424	566,598	94,542
1909	14,119,102	746,930	531,727	85,687
1910	19,143,091	788,154	626,972	164,512
1911	20,878,843	1,238,865	423,750	100,141
1912	15,523,555	2,736,739	672,176	154,565
1913	15,682,412	1,735,658	661,656	150,918
1914	18,601,384	2,878,723	731,146	191,876
	130,348,976	12,996,848	5,919,594	1,149,697

No complete data as to the distribution in Alaska of these petroleum shipments are available. In 1914 about 40,000 barrels of crude oil was shipped to Nome, where most of it was used as fuel for operating dredges. About 24,000 barrels was shipped to St. Michael and practically all of this was used as fuel by Yukon River boats.

The opening of the lignitic coal at Chicago Creek, on Seward Peninsula, would give a source of power for some of the mining operations. In the Fairhaven district, at least, it should be cheaper to use this coal than the California petroleum. If a plant were located at the coal mine it is possible that other parts of the peninsula could be supplied with electric power cheaper than that derived from imported petroleum. The development of the Nenana coal field south of the Tanana should also make it possible to furnish fuel to the Yukon River boats at lower cost than the petroleum now used. By making available the high-grade coals of the Matanuska and Bering River fields the use of California petroleum as a source of fuel would decline along the Pacific seaboard and in the basins of the tributary rivers.

It appears, therefore, that with the opening of the Alaska coal the use of California petroleum will decline relatively, if not abso-

lutely. The transition from oil to coal burners will, however, be gradual on account of the cost of new equipment, unless there should be a decided increase in the price of California petroleum.

REVIEW BY DISTRICTS.

The subjoined review is intended to summarize briefly the principal developments in all the districts. Some of the districts, including several of the most productive camps, are treated at greater length in later sections of this volume, and, therefore, the space devoted to any district here is not necessarily an indication of its relative importance. Reports on the geology of some of the districts are cited in footnotes under the respective headings.

SOUTHEASTERN ALASKA.

Nine lode-gold mines, about four placer mines, and two copper mines were operated on a productive basis in southeastern Alaska for the whole or a part of the year 1914. These mines produced 204,749 ounces of gold, valued at $4,232,538; and 34,376 ounces of silver, valued at $19,009. The copper production can not be published, as it might reveal the output of individual operators. A total of 1,712,530 tons of gold ore was hoisted in 1914.

For comparative purposes the following statistics are given for the previous year: Seven lode-gold mines, about four placer-gold mines, and three copper mines were operated on a productive basis in southeastern Alaska during 1913. These mines produced 201,360 ounces of gold, valued at $4,229,648; 29,211 ounces of silver, valued at $17,643; and 599,903 pounds of copper, valued at $92,985. A total of 1,589,746 tons of gold ore and 7,276 tons of copper ore was hoisted in 1913.

As in the previous year the most important developments were those of auriferous lodes in the Juneau district and to a lesser extent in the Berners Bay district. Important copper-mine developments started in the Ketchikan district were curtailed in the middle of the year on account of the fall in the price of copper and the unsettled financial condition. The commercial depression also affected adversely some of the auriferous lode-mine developments.

The increase of lode mining in southeastern Alaska has led to a growing interest in the development of water power. Near Juneau there have been some large installations, and in other parts of the province smaller power plants are in use. Plans are under way for other large developments, among which that of the Alaska Hydroelectric Co. has assumed definite form. This company has taken preliminary steps to construct a large hydroelectric plant at Speel River, about 40 miles southeast of Juneau.

JUNEAU AND BERNERS BAY DISTRICTS.[1]

Auriferous lode mining continued in 1914 on a large scale in the Juneau and Berners Bay districts and is described elsewhere in this report. Seven gold mines were operated, but the large developments under way have, for the most part, not yet reached a productive stage. Most of the gold output from the Juneau district came from the four mines of the Treadwell group, on Douglas Island. The first section of the mill at the Alaska-Juneau was in operation before the close of the year. The stamp mill at the Eagle River mine was operated the last three months of the year. Some gold was also won at the Jualin, incidentally to tests of the ore. No other properties were productive, but the large developments at the Alaska-Gastineau and Alaska-Juneau that have been under way for several years were continued, and these mines promise to add very considerably to the gold output in 1915. Among other developments of a considerable scale were those at the Ebner, Salmon Creek, and Kensington properties. Smaller operations were carried on at many other prospects.

KETCHIKAN DISTRICT.[2]

One gold mine, two copper mines, and one marble quarry were productive in the Ketchikan district during 1914. There was, however, much greater mining activity in the district than is indicated by the number of producing mines, notably in the development of copper ores. Incidentally some gold and copper were taken from property not here classed as productive mines.

The Rush & Brown mine, near Karta Bay, on Prince of Wales Island, was the only mine in the district which was operated throughout the year. It is reported that the sinking on the ore body was continued during the year to a depth of about 60 feet below the second level, making a total depth of 244 feet below the outcrop. The mine workings now include about 1,350 feet of drifts, 130 feet of raises, 184 feet of shaft, and a 60-foot winze.

The Jumbo mine, on Hetta Inlet, on the west side of Prince of Wales Island, was operated at its usual capacity until August 31, when it was closed because of the uncertainty of the copper market. The Alaska Consolidated Copper Co. did considerable work on five claims at Copper Mountain, on Hetta Inlet. Some work was also done on the near-by Red Wing and Bruce properties. Developments were continued at the Big Harbor mine, on the west side of Prince of Wales Island. Here the shaft was sunk to a depth of 117 feet, and

[1] Spencer, A. C., The Juneau gold belt: U. S. Geol. Survey Bull. 287, 1906. Knopf, Adolph, Geology of the Berners Bay region, Alaska: U. S. Geol. Survey Bull. 446, 1911; The Eagle River region, southeastern Alaska: U. S. Geol. Survey Bull. 502, 1912.

[2] Wright, F. E. and C. W., The Ketchikan and Wrangell mining districts, Alaska; U. S. Geol. Survey Bull. 347, 1908. Wright, C. W., Geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska: U. S. Geol. Survey Prof. Paper 87, 1915.

this shaft, 200 feet of drifts, and 150 feet of adit are reported as the total underground work up to the close of 1914.

The Granby Consolidated Mining, Smelting & Power Co. in 1913 took over the Mamie copper mine near Hadley, on Prince of Wales Island, and in April, 1914, began large-scale operations which were continued until September. Besides the surface improvements some 750 feet of underground work was done.

Some developments were made during the first half of the year on It, Dean, and Mount Andrew properties, all on the southwest side of Kasaan Peninsula. The underground work at the Cymru mine, which has not been operated for several years, was extended in the first half of 1914, 100 feet of drifting and stoping being reported. This makes the total mine workings 100 feet of shaft and 500 feet of drifts.

The Jackson group of copper claims is on Lake Bay, an indentation of the northeast shore of Prince of Wales Island, about 60 miles northwest of Ketchikan and 40 miles southwest of Wrangell. Here a tram has been built to the beach and considerable underground work completed. Some test shipments of ore were made in 1914. In addition to those above listed, there are probably other copper developments in the Ketchikan district which have not been reported.

The Dunton gold mine (also known as the Julia or Rodgers mine), near Hollis, on Prince of Wales Island, is equipped with a 5-stamp mill and was productive in 1914. The total underground workings include an incline 200 feet deep and about 200 feet of drifts. Some developments were also made at the Crackerjack and Ready Bullion mines, near the Dunton mine. The Cascade claims, also in this district, were developed in a small way during 1914, ore being treated in an arrastre and in a small stamp mill.

The mill at the Valparaiso gold mine, near Dolomi, Prince of Wales Island, was not operated in 1914. Underground work, however, was continued, and the completion of 450 feet of drifting during the year is reported. Only assessment work is reported on other claims in the vicinity of Dolomi.

Until the European war broke out the Alaska Venture Syndicate, an English company, continued work on the Old Glory claims, near Smuggler Cove, on the mainland 30 miles northwest of Ketchikan. An air compressor, operated by water power, has been installed, and a total of 900 feet of underground work was done in 1914. Some work was also done at the Gold Standard property, which has long been idle, on the King & Elliot claims, both in the same region. The Gold Mountain group, also in this part of the district, is reported to have been developed by 300 feet of adit, and several test shipments of ore are said to have been made from this property. The Old Sealevel mine, on Revillagigedo Island south of Ketchikan, which

has long been idle, is reported to have been pumped out in 1914 for the purpose of examination.

The large marble quarries[1] near Tokeen, on Davidson Inlet, in the northwestern part of the Ketchikan district, were operated on about the same scale as in previous years. There was also some prospecting of marble deposits in other parts of the district, but of this work there is no definite report at hand. Some work was done in 1914 by Charles Sulzer on a barite deposit near Hetta Inlet, on the west side of Prince of Wales Island.

YAKATAGA DISTRICT.[2]

In 1914 the hydraulic placer mine on White River, in the Yakataga district, was operated throughout the season, which extended from about May 1 to October 25. In addition to this there was some mining of beach placers at Yakataga, but the value of the entire output from beach mining did not exceed $3,000 or $4,000. There were no other developments in the Yakataga district.

KATALLA AND BERING RIVER DISTRICTS.[3]

The only productive mining in the region tributary to Katalla consisted in the operations of the Alaska Oil & Refining Co. This company has five wells, from which oil has been produced by pumping and one of which was drilled in 1914. The oil is used chiefly at a small refinery owned by the same company, and the products are disposed of in a local market.

Patent has been granted to one coal claim in the Bering River field. In other respects there has been absolutely no development, as has been the case for many years.

OTHER DISTRICTS.

The Chichagof gold mine, in the Sitka district,[4] was operated throughout the year. The mine development in 1914 included about 1,800 feet of drifts and cuts. Five stamps and a 12-foot tube mill were added to the equipment, making 25 stamps in all. At the Hurst property, which is in the same region, a 300-foot adit was driven in 1914. A new gold-bearing vein on which some work was done is said to have been discovered in the same district by Richard Hofstad and Ole Johnson. The gypsum mine, on the east side of Chichagof Island, is said to have been worked on about the same scale as in previous years.

---

[1] Burchard, E. F., Marble resources of the Ketchikan and Wrangell districts: U. S. Geol. Survey Bull. 542, pp. 52–77, 1913.

[2] Maddren, A. G., Mineral deposits of the Yakataga district: U. S. Geol. Survey Bull. 592, pp. 119–153, 1914.

[3] Martin, G. C., Geology and mineral resources of the Controller Bay region, Alaska: U. S. Geol. Survey Bull. 335, 1908.

[4] Knopf, Adolph, The Sitka mining district, Alaska: U. S. Geol. Survey Bull. 504, 1912.

In 1914 three hydraulic plants were operated or in process of construction in the Porcupine district, which is tributary to Haines, on Lynn Canal. Another is in course of construction on Salmon River, in the same region. Some excitement was caused in this district by the discovery in June, 1914, of a rich placer near Pleasant Camp, close to the international boundary. It appears that this deposit is not very extensive.

Though copper ores, galena, marble, and other mineral deposits are found in the Wrangell district, there is as yet but little mining. In 1914 there was some development of galena deposits in the Groundhog, and some test shipments of ore were made. E. E. Harvey is developing a copper property on the west side of Wrangell Narrows, and is said to have done some 200 feet of underground work. Developments continued on some marble deposits in this district. Some garnets were shipped from the garnet mine near Wrangell.[1]

COPPER RIVER REGION.

Mining in the Copper River region includes the development of copper mines in the Kotsina-Chitina copper belt and placer mining in the Nizina and Chistochina districts. There is also a little placer mining in the Bremner River region and in the Nelchina district and some lode prospecting in different parts of the Copper River basin.

The mining developments in the Chitina basin are described at length elsewhere in this volume. In this district two copper mines, the Kennecott-Bonanza and the Mother Lode, were productive in 1914, and some copper was also shipped from the Kennecott-Jumbo property. Among the developments in the district are those by the Great Northern Development Co., Hubbard & Elliot Co., and Alaska Consolidated Copper Co., and those on the Westover and Rarus claims. None of these properties are in a productive stage, and they will require railroad construction before they can ship ore.

Three large hydraulic plants were operated in the Nizina district in 1914, and there were also some smaller operations in the same field. A little placer mining was also done in the Bremner River basin and in other parts of the lower Copper River region. The placers discovered in the basin of Nelchina River, tributary to Tazlina River, in 1913 have not proved either rich or extensive. Auriferous gravels were found on several creeks, but only those on Albert Creek have proved rich enough to exploit, and the output of gold so far has been insignificant. This district is described elsewhere in this report.

About 10 placer mines were operated in the Chistochina district in 1914. It is estimated that about 100 men were engaged in mining and

[1] Brooks, A. H., The mining industry in 1912: U. S. Geol. Survey Bull. 542, p. 51, 1913.

prospecting in this field. Two hydraulic plants were operated on Slate Creek; the other placers were worked by pick and shovel. Some work was done in preparation for the installation of a hydraulic plant on Hidden Treasure Creek. Plans were made for prospecting some dredging ground on the Chisna. Operators report that the sluicing season was exceptionally short. One flood early in the summer seriously interfered with some of the work.

PRINCE WILLIAM SOUND.

Two copper mines and eight gold-lode mines were operated in the Prince William Sound region in 1914. The value of the total mineral production of the region in 1914 was $1,198,742, compared with $1,327,950 in 1913. This decrease is due to the fall in price of copper. The mining industry on Prince William Sound is fully treated elsewhere in this volume; therefore only its principal features will here be referred to.

The Beatson Bonanza and Ellamar copper mines continued throughout the year on their normal shipping basis. An aerial tram was nearly completed, and considerable underground work was done on the Midas copper mine, near Valdez, by the Granby Co. before the decline in value of copper led to the closing of the plant. Some copper developments were also made on half a dozen other properties on the sound.

The Cliff gold mine, near Valdez, was operated until early in the summer. A mill was installed during the summer on the Ramsay & Rutherford property, in the same district, and some gold was produced on this as well as on the Cameron & Johnson, Gold King, Mountain King, and several other properties. The mill at the Granite mine, in the Port Wells district, was operated for practically the entire year. A smaller plant was installed in the fall on the Gold Eagle property, in the same district. There was also considerable prospecting of other auriferous lodes in the Port Wells region.

KENAI PENINSULA.[1]

The value of the total gold production of Kenai Peninsula in 1914 is estimated to be $70,000, compared with about $50,000 in 1913. Though there was much prospecting and initial development work looking toward lode and placer mine development in the peninsula, no important advances were made. Lode mining continued during the year on only a very small scale, but there was some improvement in the placer-mining industry. It seems probable that attempts are

[1] Martin, G. C., Johnson, B. L., and Grant, U. S., Geology and mineral resources of Kenai Peninsula, Alaska: U. S. Geol. Survey Bull. 587, 1915.

soon to be made to develop some of the larger bodies of auriferous gravels whose low tenor has not permitted profitable exploitation under present methods of operation. Now that the northeastern part of the peninsula is to be served by a government railroad greater prosperity in the mining industry seems assured. About 20 placer mines and four lode mines were operated during the summer on Kenai Peninsula. As the total value of the output of the lode mines, including also four prospects, was less than $26,000, it can be seen that they were all small operations.

The Skeen-Lechner mine was operated during the first six months of 1914. Most of the underground work was done on the 200-foot level. The equipment consists of a 4-stamp and a 10-foot Chilean mill. Some rich ore was mined on the Grant Lake property and treated in a small customs mill at Seward. The underground work at this mine is reported as including a 20-foot shaft, 75 feet of adit, and 50 feet of drifts. At the Lucky Strike mine, near Hope, a 1-stamp prospecting mill was used to treat some ore, which was taken out of a 35-foot adit. A similar equipment was used on the Ophir and Columbia claims to treat gold ore taken from the property. Work was continued at the Primrose mine, on Porcupine Creek, where considerable underground work has been done.

In the Moose Pass region J. C. Gilpatrick continued work on his property. The ore was treated in an arrastre. The Moose Pass Mining Co. has opened its property in the same district by an adit and crosscuts. Its equipment includes a 1-stamp prospecting mill. An arrastre was also operated on a claim on Colorado Creek. Work was continued on the property of the Gold Stamp Mining Co., on Bear Creek; over 900 feet of underground work has been done at this mine. Other quartz-mining developments took place, but there are no data at hand relating to them.

Placer mining was carried on in 1914 on Crow, Resurrection, Bear, Canyon, Sixmile, Winner, Gulch, Mills, Quartz, and Cooper creeks. Of these the first four were the largest producers. About 10 hydraulic plants were operated on Kenai Peninsula in 1914. The largest of these are those of Nutter & Dawson on Crow Creek,[1] the Matthieson Mining Co. on Resurrection Creek, and the Kenai Mining & Milling Co. on Cooper Creek. A number of other hydraulic plants are in process of installation.

The two dredges on Kenai River were not operated in 1914. There was, however, some extensive prospecting with churn drill on the lower parts of Sixmile and Resurrection creeks. This work was done with a view of installing dredges.

[1] Crow Creek is north of Turnagain Arm but is usually included with the Kenai Peninsula placers.

SOUTHWESTERN ALASKA.

Work was continued at the Amok gold-lode mine, on the west side of Kodiak Island, but so far as known this property was not productive. Some work was also done by F. R. Brennan on an auriferous quartz vein on the north side of Viekoda Bay (locally known as Little Uganik Bay). An adit tunnel some 56 feet in length has been driven on this vein. The only other mining on Kodiak Island consisted in some small operations on beach placers. Some volcanic ash was shipped from Kodiak to be used as an abrasive.

It is reported that some low-grade placers have been found on Raspberry Island, adjacent to the northwest end of Kodiak Island. Some beach mining also continued at Popof Island, near Unga. The total gold produced in 1914 from beach mines of Kodiak and other places in southwestern Alaska is estimated to have a value of about $4,000. Plans are being made to construct a cyanide plant to work over the tailings of the Apollo mine, on Unga Island. In the Iliamna[1] and Mulchatna regions there was no production except a small output from placers. Two hand drills were used to test placer ground on Bonanza Creek, a tributary of Mulchatna River. Developments were continued on the Duryea & McNeil and Cook & Bornland properties in the Iliamna region. Mining engineers visited the Iliamna district in 1914 to examine some of the copper and gold lodes.

SUSITNA-MATANUSKA REGION.

The developed mineral resources of the Susitna-Matanuska region include the Willow Creek gold-lode district, the Yentna and Valdez Creek placer districts, and the Matanuska coal field. A little placer mining has also been done on Willow Creek and on tributaries of the upper Chickaloon. Some copper ore has been found on Sheep Mountain,[2] in the upper Matanuska basin, and on Iron Creek,[3] in the Talkeetna River basin. There have also been reported discoveries of large low-grade lode deposits in the Broad Pass region, of the upper Susitna, but authentic information in regard to these deposits is lacking. It should be added, however, that what is known of the geology of the Broad Pass region[4] seems favorable to the occurrence of metalliferous deposits. The Susitna and Broad Pass route has been selected for the Government railroad from Seward to Fair-

[1] The writer is indebted to the late Mr. Thomas W. Hanmore, U. S. Commissioner at Iliamna, for information about the Iliamna and Mulchatna regions.

[2] Martin, G. C., and Mertie, J. B., jr., Mineral resources of the upper Matanuska and Nelchina valleys: U. S. Geol. Survey Bull. 592, pp. 281–282, 1914.

[3] Brooks, A. H., The mining industry in 1910: U. S. Geol. Survey Bull. 480, pp. 32–33, 1911.

[4] Moffit, F. H., Preliminary report on the Broad Pass region: U. S. Geol. Survey Bull. 592, pp. 301–305, 1914. Complete report to be issued as Bulletin 608, now in press.

banks. The assurance of railroad communication will give a strong impetus to prospecting in this field, a condition which has to some extent been anticipated by the developments made in 1914.

In 1914 three auriferous lode mines and about 24 placer mines were operated in the Susitna-Matanuska region, and the value of their total gold output was $357,184. In 1913 the same region produced gold to the value of $155,000. This increase is to be credited to the Willow Creek lode district.

WILLOW CREEK DISTRICT.[1]

Three lode mines operated in the Willow Creek district in 1914 milled 10,110 tons of ore, yielding $297,184 worth of gold. One hydraulic placer mine was also operated at the mouth of Grubstake Gulch, in this district, from June 22 to September 15. Some placer ground on Willow Creek was prospected by another company, and incidentally some gold was recovered.

The Gold Bullion mine was operated from June 19 to September 8, and about 500 feet of underground work was done. A cyanide plant having a daily capacity of 45 tons was added to the surface equipment. The underground work at the Alaska Free Gold Mining Co.'s plant aggregates 300 feet, and the mine was operated from June 1 to November 1. A second Lane mill and a cyanide plant were added to the equipment but were not operated in 1914. The Alaska Gold Quartz property was taken over by the Independence Gold Mining Co. in 1914. The operations at that time were conducted on about the same scale as in previous years, but work has been started on the enlargement of the reduction plant, a 4-stamp mill. About 500 or 600 feet of underground work has been done on this property. Considerable development work was done on the Rosenthal and other prospects in the Willow Creek district, but detailed information about it is lacking.

The developments in the Willow Creek district thus far have been on a relatively small scale. With the assurance of railroad connection with Seward at an early date, undoubtedly the feasibility of larger operations will receive careful investigation. There seems to be justification for the opinion that the quantity of ore available will permit larger installations. The three mills thus far erected are all at high altitudes, where water is to be had only from about June to October. If reduction plants were built in some of the larger valleys there is no reason why the mills should not be operated throughout the year. When the Matanuska coal field is opened cheap fuel will be assured. There are in the region, moreover,

[1] Capps, S. R., The Willow Creek district, Alaska: U. S. Geol. Survey Bull. 607 (in press). See also abstract in Bull. 592, pp. 255–272.

some good water powers[1] which are available during at least seven months of the year.

YENTNA DISTRICT.[2]

The season of 1914 was not favorable to placer mining in the Yentna district on account of the low water in July. It is estimated that about 25 plants were operated during the summer, employing some 60 to 100 men. Unfortunately, many of the operators did not report their gold output, so that reliable figures on gold production are not available. It is estimated, however, that the total output in 1914 had a value of about $50,000. Plans were made for larger operations in this field, and it is probable that a dredge will be installed on Cache Creek in 1915, while other dredging ground is being prospected.

Though there has been no lode development in the Yentna district, some auriferous veins have been prospected. A rich vein is reported to have been discovered on Nugget Creek in 1914.

VALDEZ CREEK DISTRICT.

Developments continued on Valdez Creek,[3] a tributary of the headwaters of the Susitna, which carries valuable gold placers. Up to a few years ago placer mining in this field was confined to small operations. In the fall of 1914 the installation of a large hydraulic plant on this creek was completed and some sluicing was done. There were also a few other small operations in this district.

MATANUSKA BASIN.[4]

As in previous years there were no developments in the Matanuska coal field in 1914. The coal mined for a navy test was brought to the coast in the winter of 1913–14, and the preliminary statement of the results of this test is presented elsewhere in this volume (pp. 27–30). A little placer mining was done on some of the upper tributaries of Chickaloon Creek.

YUKON BASIN.

PRODUCTION.

The value of the gold output of the Alaska Yukon district in 1914 is estimated to have been $7,795,421, compared with $8,130,000 in 1913. It is estimated that about 500 placer mines were operated in

[1] Ellsworth, C. E., and Davenport, R. W., Preliminary report on a water-power reconnaissance in south-central Alaska: U. S. Geol. Survey Bull. 592, pp. 189–192, 1914.

[2] Capps, S. R., The Yentna district, Alaska: U. S. Geol. Survey Bull. 534, 1913.

[3] Moffit, F. H., Headwater regions of Gulkana and Susitna rivers, Alaska: U. S. Geol Survey Bull. 498, 1912.

[4] Martin, G. C., and Katz, F. J., Geology and coal fields of the lower Matanuska Valley: U. S. Geol. Survey Bull. 500, 1912.

the Yukon camps in 1914, giving employment to about 3,500 men. Only four lode mines were productive in the Yukon basin in 1914, and these were all in the Fairbanks district. A number of other properties produced some gold incidental to development.

The important placer camps of the Yukon basin, together with their gold output in 1914, are listed in the following table:

Estimated value of gold produced from placers in the Yukon basin, by districts, 1914.

District.	Value.	District.	Value.
Fairbanks	$2,500,000	Circle	$215,000
Iditarod	2,060,000	Innoko	200,000
Ruby	1,000,000	All others	335,000
Hot Springs	750,000		
Koyukuk	260,000		7,570,000
Chisana	250,000		

The Yukon placer mines also produced $35,602 worth of silver. These figures do not include the output of lode mines, which in 1914 produced gold to the value of $225,421 and silver to the value of $2,209. There was no other productive form of mining in the Yukon basin except the recovery of stream tin incidental to gold placer mining in the Hot Springs district.

PLACER DISCOVERIES.

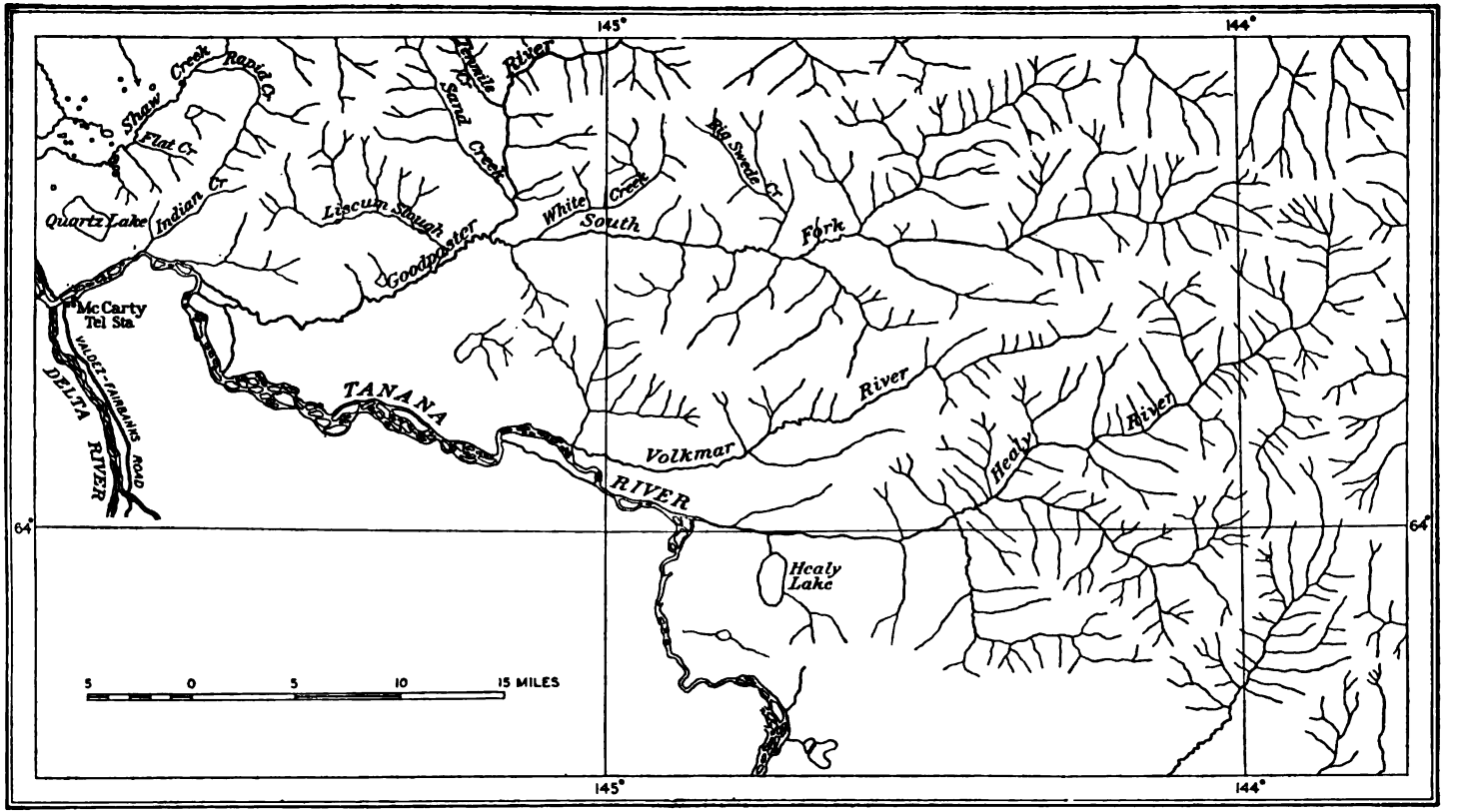
The only new localities where placer gold was discovered in the Yukon region during 1914 were in the Healy River and upper Tolovana River basins. Both these rivers are tributary to the Tanana. Neither of these camps has been visited by Survey geologists since the discoveries were made, and information regarding the reported finds is meager.

Healy River flows into the Tanana from the north about 170 miles above Fairbanks. The lower part of its valley has not been surveyed, but the accompanying map (Pl. I) shows its general location and the details of drainage in the upper basin.

The bedrock of the region[1] so far as known is mica schist with gneissoid and massive granites. The mineralization is probably connected with the intrusion of granites, as it is in other parts of the Yukon-Tanana region.

Several years ago some auriferous gravels were found on Ruby Creek in this district. Ruby Creek is tributary to Healy Lake, which is in the flood plain of Healy River about 4 miles from the Tanana. In the midsummer of 1914 some excitement was caused at Fairbanks by the reported discovery of valuable placers in the Healy

[1] Brooks, A. H., A reconnaissance in the White and Tanana River basins, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 425–494, 1900.



MAP SHOWING LOCATION OF HEALY RIVER.

River region, and probably more than a hundred men went to the scene. It was found that the discovery was of no great promise and but few remained to prospect. So far as can be learned the actual find consisted of some auriferous gravels on Kenyon Creek, a tributary to Healy Lake, about 4 miles from its mouth. The gravels are reported to be 125 feet deep and the pay streak about 60 feet wide. Many garnets are found in concentrates, and as the bedrock is reported to be schist it is probably a garnetiferous mica schist. The gold is medium grained with but few nuggets, angular and bright colored. Its value is probably about $14 to $16 an ounce. In spite of the discouraging reports of this find a number of prospectors undertook to test the gravels of Kenyon and other creeks of the district. What is known of the geology of the region justifies the hope of finding gold placers.

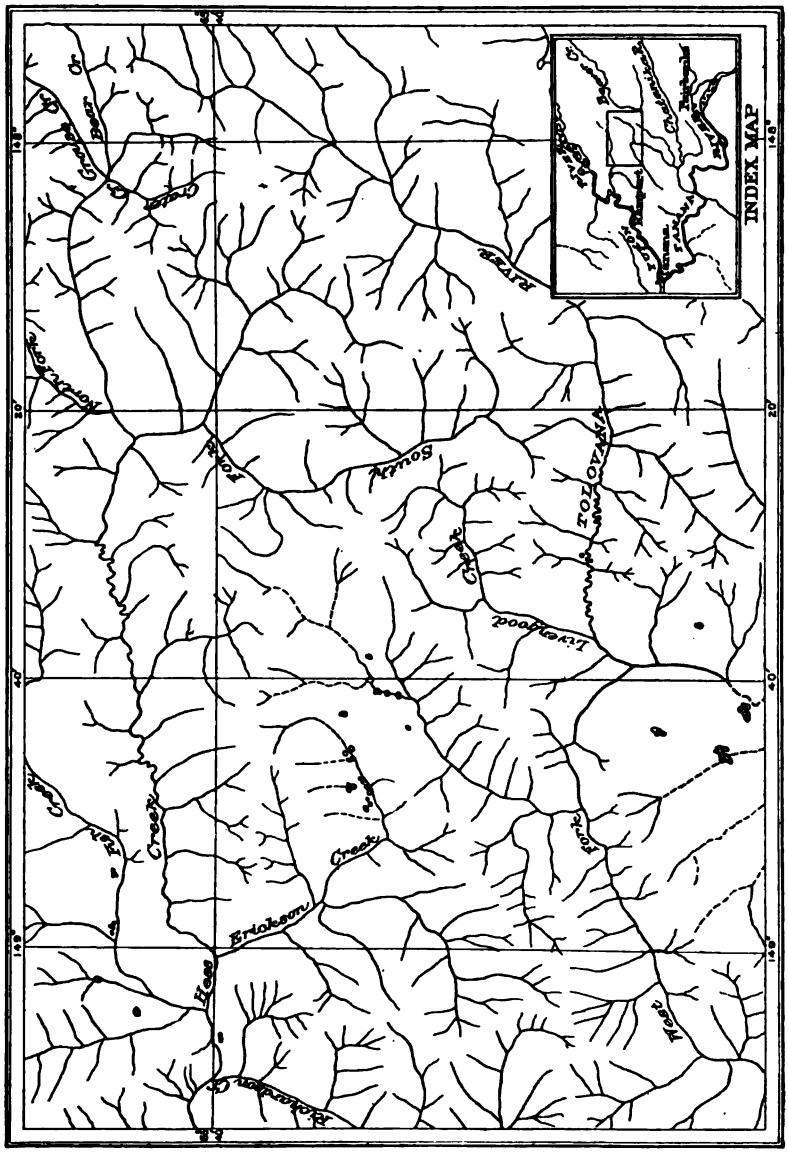
Healy River may be reached from Fairbanks by small launches ascending the Tanana, though navigation is difficult on account of shoals, driftwood, and swift water. There is a good wagon road as far as McCarty, at the mouth of Delta River, about 90 miles from Fairbanks. McCarty is about 60 miles by river route from the mouth of Healy River. This district lies in the Tanana recording precinct, and the recording office is at Richardson.

In September, 1914, it was reported at Fairbanks that rich placers had been found in the headwater region of Tolovana River (see fig. 1), a tributary of the lower Tanana. The Tolovana drains the southern slope of an upland forming the watershed between it and Hess Creek on the west and northwest and Beaver and Victoria creeks on the east and northeast. To judge by what is known of adjacent regions,[1] the country rock of the new district is probably limestone and slate with some greenstone and, probably, intrusive granites. The geology is probably more like that of the Hot Springs district than that of the Fairbanks district.

According to the newspaper accounts, the first claims recorded in this district were in the names of C. W. and N. R. Hudson, Jay Livengood, and C. W. Koegly, and these men were presumably the discoverers. The first claims staked were on what was called Livengood Creek, which is tributary to the upper Tolovana. Placer gold is reported to have been found at the same time on Olive Creek, a tributary to the Tolovana just above Livengood Creek. Later other creeks were staked, including some tributaries to Hess Creek. There appears to be no question that auriferous gravels are distributed over a considerable area in this new district, but there is still a question as to how much of this offers workable placers. The alluvium on many of the creeks is said to be from 20 to over 100 feet in depth,

[1] Prindle, L. M., and others, A geologic reconnaissance of the Fairbanks quadrangle, Alaska: U. S. Geol. Survey Bull. 525, 1913.

and hence the work of prospecting is necessarily slow. During the winter of 1914–15 several steam plants were taken into the district, and the results of the winter's work should yield some definite evi-


INDEX MAP
Livengood
Tolovana
Hess
Erickson
Creek
Fork
River
Bonanza
Hess Creek
Erickson Creek
Livengood Creek
Tolovana River
Bonanza Creek
Fork
Hess Creek
Fork
Tolovana River
Fork
Hess Creek
Fork
Tolovana River
Fork
Hess Creek
Fork
Tolovana River

which in an air line is 50 miles from Livengood Creek. The trail thus far used to the new camp leaves Olnes, a station on Tanana Valley Railroad, and takes a northwesterly course. It is probably 50 or 60 miles in length. This trail has been used only in winter, but there will be no serious difficulty about establishing a summer trail, though the flats of the larger rivers are likely to prove swampy.

Another route of approach is by launch or small steamer up Tolovana River. This watercourse is a deep, winding, sluggish stream, but log jams are likely to present difficulties to navigation. It is reported that small steamers can be taken within 10 or 20 miles of the new camp. Livengood Creek is about 40 miles due east of the Yukon at the mouth of Hess Creek, which can be ascended in small boats to points within 10 or 15 miles of the new camp. Though the district is not very difficult of access, it will be rather expensive to reach with heavy machinery. Several hundred persons are said to have wintered in the new camp.

FAIRBANKS DISTRICT.[1]

The first placer mining in the Fairbanks district consisted of some small operations in 1903. Up to 1908 the gold output steadily increased, but since then it has been on the decline. In these 12 years of operations gold to the value of $63,040,000 has been won from the auriferous gravels. The placer gold and silver output by years is shown in the following table. Silver occurs as an impurity in the placer gold, and the production of this metal as stated in the table is based on an estimate of its percentage.

Placer gold and silver produced in the Fairbanks district, 1903 to 1914, inclusive.

Year.	Gold.		Silver.	
	Fine ounces.	Value.	Fine ounces.	Value.
1903	1,935.00	$40,000	348	$188
1904	29,025.00	600,000	5,225	2,821
1905	290,250.00	6,000,000	52,245	28,212
1906	435,375.00	9,000,000	78,367	42,318
1907	387,000.00	8,000,000	69,660	37,616
1908	445,050.00	9,200,000	79,909	43,151
1909	466,818.75	9,650,000	84,027	45,375
1910	295,087.50	6,100,000	53,116	28,683
1911	217,687.50	4,500,000	52,245	27,690
1912	200,756.25	4,150,000	48,182	29,632
1913	159,637.50	3,300,000	20,274	12,245
1914	120,937.50	2,500,000	29,024	16,050
	3,049,560.00	63,040,000	572,622	313,981

The data relating to the source of the gold by creeks are not very accurate. Attempt has been made in the following table, however,

[1] Prindle, L. M., and others, A geologic reconnaissance of the Fairbanks quadrangle, Alaska: U. S. Geol. Survey Bull. 525, 1913.

to distribute the total Fairbanks placer-gold production up to and including 1914 by the creeks on which the mines are located.

Approximate distribution by creeks of value of placer gold produced in Fairbanks district, 1903 to 1914, inclusive.

Cleary Creek and tributaries	$21,600,000
Goldstream Creek and tributaries	12,400,000
Ester Creek and tributaries	10,300,000
Dome Creek and tributaries	7,300,000
Fairbanks Creek and tributaries	6,700,000
Vault Creek and tributaries	2,400,000
Little Eldorado Creek	1,800,000
Other creeks	540,000
	63,040,000

The above tables show only the placer output of the district immediately tributary to Fairbanks. They do not include the output of Bonnifield, Tenderfoot, Salchaket, and other smaller camps which are supplied from Fairbanks and whose gold is sent to Fairbanks. Several other districts, such as Hot Springs and Ruby, send a part of their gold output to Fairbanks. All these districts have added from $500,000 to $1,500,000 of gold to the total which annually passes through Fairbanks.

Lode mining began at Fairbanks in 1910, and since that time gold to the value of $851,069 has been produced by this industry. The lode output by years is shown in the following table, which is based on more accurate data than those used for the placer production:

Lode gold and silver produced in the Fairbanks district, 1910 to 1914, inclusive.

Year.	Gold.		Silver.	
	Fine ounces.	Value.	Fine ounces.	Value.
1910	841.19	$17,389	106	$57
1911	3,103.02	64,145	582	308
1912	9,416.54	194,657	1,578	971
1913	16,904.98	349,457	4,124	2,491
1914	10,904.75	225,421	2,209	1,222
	41,170.48	851,069	8,599	5,049

The very marked decline in the gold-mining industry of the Fairbanks district is chargeable to the economic conditions and not to the exhaustion of the gold deposits. While it is true that the exploitation of bonanza placers in this field will soon be a thing of the past unless discoveries not now anticipated are made, yet large bodies of auriferous gravels remain, but only a small part of them can be profitably exploited under present operating costs. With the rapid exhaustion of the easily accessible timber wood is increasing in cost.

The operator who now works on placers of lesser gold tenor than those handled by his predecessor of a few years ago (see pp. 78, 79) is forced to pay two or three times as much for fuel. Operators also report that during the last two years the cost of supplies has increased somewhat at Fairbanks. Therefore the average cost of everything necessary to gold mining except labor is greater now than in the past. Under these conditions there is not much incentive to embark on new mining ventures.

There is need, therefore, of cheaper fuel and cheaper transportation, and these needs will be met by the proposed Government railroad to Fairbanks. This railroad will lower the cost of freight, will make communication possible throughout the year, and will furnish cheaper fuel by bringing in the coal from the Nenana field. Under such conditions large placer-mining operations will surely be undertaken and Fairbanks will maintain its position as an important placer camp.

The conditions that have brought about a decline of placer mining have had a still more depressing effect on the lode mines. The enthusiasm aroused by the first lode developments led many to embark on ventures without counting the cost of operation. It is now certain that there can be little hope of substantial profit until mining and milling costs are reduced, chiefly by obtaining cheaper power. Many owners of quartz mines are now awaiting the construction of the railroad, which will give them cheaper fuel and supplies, before proceeding with any development. While these conditions brought about the general decline in lode mining, it is also true that many veins have not shown the persistency in depth and value that their owners had hoped for. Such unrealized hopes are to be expected in all new lode camps.

It is estimated that 125 placer mines were operated in the Fairbanks district in the summer of 1914, employing about 1,200 men. During the previous winter probably less than 50 mines were operated. One dredge was operated during the entire summer on Fairbanks Creek, but this is the only attempt that has been made to exploit the extensive gold dredging ground. About half of the gold mined during the year was taken from the placers of Goldstream and Cleary creeks. Details regarding mining operations at Fairbanks are presented elsewhere in this volume.

ITIDAROD DISTRICT.[1]

The value of the gold produced in the Iditarod district in 1914 is estimated to be $2,060,000, compared with $1,860,000 in 1913. Much the greater part of the Iditarod output is taken out by a few large

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, 1914.

plants. Both the high cost of mining and the character of the deposits make the Iditarod the field of large operations. This is shown by the fact that only about 15 mines were worked in 1914, employing probably about 500 men. The most important operations are those of the two dredges, one on Flat Creek and the other, which began work this season, on Otter Creek. A new electric plant was being constructed in 1914 on the Iditarod about 10 miles above Otter to furnish power to the Flat Creek dredge. As in previous years most of the gold output was derived from Flat and Otter creeks. The following notes were collected by A. G. Maddren during a brief visit to Iditarod in July:

The principal new development in the mining industry of the Iditarod district during 1914 is the installation of a gasoline dredge on Otter Creek by Riley & Marston. This is of the small-flume washing type that has been used in the Nome district during the last few years. Its capacity in favorable gravels is from 2,000 to 2,500 cubic yards in 24 hours on a fuel consumption of 250 to 300 gallons. In July, 1914, this machine was operated along the right limit of Discovery claim, on the present bed of Otter Creek and its immediate banks. Many of the water-front buildings of the settlement of Discovery were removed in consequence of its operation.

The gravels in the immediate channel of Otter Creek are thawed, but the right bank, on which the town stands, is mostly frozen, especially in its upper 5 to 10 feet, which is composed chiefly of muck. Steam thawing and blasting in advance of the dredge were necessary to remove this frozen overburden. A considerable number of bowlders too large for the dredge to lift occur in the stream bed and right bank, where they were dug out until July 15, and the delays caused by their removal hindered the dredge from working at full capacity. A double crew of about 12 men was employed.

On Flat Creek the large electrically driven dredge of the Yukon Gold Co. continued its successful operation of the last four years. In July this machine was digging downstream along the west boundary of the Wildcat Association claim near its lower limit and on the adjoining Chicago Bench claim. About 60 men were employed in this dredging operation.

During 1913 two placer mines were operated on a bench claim along the right limit of the Wildcat Association, beyond the dredgeable area, and it was planned to continue this work during 1914 as soon as the rains of August and September furnished sufficient water for sluicing. This bench is mined by open-cut scraping and hoisting methods such as were generally employed along Flat Creek before the more efficient dredge was installed. About 10 men were engaged on this bench in July, but it was intended to double the force as soon as water for sluicing was available.

Several open-cut scraping and hoisting plants were also in more or less continuous operation on Otter Creek on claims 1 above and 1 below Discovery claim. The largest of these plants used a bottomless scraper of 2½ cubic yards capacity. About 30 men were employed on these plants.

At the mouth of Glen Gulch a small hydraulic plant of small capacity, supplemented by shovel work, was under operation by two men, and on the lower part of Black Creek a plant was employing six to eight men in July

The open-cut pit mining of the residual placer deposits on the higher slopes of Flat Dome was continued in the Flat Creek, Happy Gulch, and Chicken Creek drainage basins. On the Up-Grade Association and Chicken Creek operations

steam derricks have been installed to handle the large residual granitic bowlders that encumber the gold-bearing deposits. The mining of these properties had not reached full capacity early in July, owing to the lack of water for washing the loosely consolidated residual granitic sands that contain the placer gold. But double shifts of about 10 men were then employed on each of these operations and it was planned to increase the force as soon as the rains of August and September furnished more water for ground sluicing and concentrating the pay dirt. Work was also continued on the Hilltop Association group at the source of Happy Gulch. There were other operations on Otter and Flat creeks, as well as on Black, Willow, and some other creeks of the district. Winter deep mining was carried on by only a few small plants in the Iditarod district.

RUBY DISTRICT.

It is estimated that the Ruby district, including the tributaries to the north, produced about $1,000,000 in 1914, compared with $785,000 in 1913. About 55 different mines were operated during the summer, employing about 450 men. Probably about 20 mines were worked in the winter, employing about 200 men.

The Ruby district embraces an ill-defined area in which auriferous gravels are widely distributed stretching southward from the Yukon at the town of Ruby. The center of most extensive mining at present is the basin of Long Creek. There is also considerable mining on Glenn Gulch and other tributaries of Flint Creek. All these creeks drain into Solatna River, many of whose other tributaries carry gold placers. Since 1912 the mining field was extended by the finding of gold on Poorman Creek, which lies within the basin of the upper Innoko, about 50 miles south of the Yukon. Mining and prospecting were particularly active in this part of the field during 1914. As, unfortunately, not all the operators returned the schedule sent to them requesting data on mining operations, the following notes on mining are far from being complete, but they will serve to indicate the principal operations in the district.

The largest placer-mine operations during the summer of 1914 were on Long Creek and its tributaries. On Long Creek proper there were eight or ten large plants working on deep gravels and employing from 20 to 50 men each, besides some smaller mines. Some of these were operating during the previous winter. Three or four large plants were also working the shallower gravels of Bear Pup, a tributary of Long Creek. This work was done by open-cut methods. There was also considerable mining, though no large single operations, on Midnight, Greenstone, and Monument creeks, all tributary to the upper Solatna. Considerable ground was stripped on Greenstone Creek, besides some large open-cut operations, with the purpose of mining on a large scale next season, either by dredges or steam scraper. One deep mine was operated on Tamarack Creek,

tributary to the Solatna from the south, also on its tributary Willow Gulch.

Data from the eastern part of the district are especially scant. It is known that there was considerable deep mining on Glenn Gulch, and deep mining is also reported on Trail Creek. Undoubtedly there were many other small operations.

The writer is greatly indebted to Mr. Alexander Cameron for notes on mining developments in the Poorman Creek region. Freight to this camp from the Yukon cost 4 cents a pound in winter and 8 cents in summer. The summer freight is brought part way by boat up Solatna River. According to Mr. Cameron eight claims, employing 30 men, were operated in this part of the district during the winter and sixteen, employing 76 men, during the summer. These produced gold to a total value of about $120,000. On Poorman Creek four claims were worked in winter and eight in summer. All these are underground mines. Seven of the mines are equipped with engines of about 20 horsepower each. The placer gold is reported to be irregularly distributed, and this makes operations expensive. One deep mine was operated on Little Pup, a tributary of Poorman Creek. The bedrock here is about 60 feet deep. Most of the material above bedrock is muck. It contains a pay streak 5 to 18 feet wide, which is reported to carry good values. One mine was operated on Duncan Creek, which is also tributary to Poorman Creek. Here the bedrock is 50 to 75 feet in depth, and the distribution of gold seems to be rather irregular, though the creek has been little prospected. Flat Creek joins with Poorman Creek to form Timber Creek. Here there were two mines operated in the winter and one in the summer. The bedrock is about 60 feet deep.

HOT SPRINGS DISTRICT.

The gold placers of the Hot Springs district produced gold to the value of about $750,000, compared with $400,000 in 1913. About 40 mines, large and small, were operated in this district in 1914, employing some 300 men. The largest operations of the district were in the Sullivan Creek basin. Some stream tin was recovered incidentally to gold placer mining. Details regarding mining in this district are presented elsewhere in this volume.

KOYUKUK DISTRICT.

It is estimated that the Koyukuk district produced in 1914 gold to the value of $260,000; in 1913 the output was about $400,000. The decrease was due in part to lack of water, but largely to the fact that in 1913 one or two deep mines on Hammond River worked on very rich ground and thereby abnormally increased the total

output. So far as can be learned, the value of the annual gold output from the Koyukuk district has for a number of years been from $200,000 to $300,000. It is estimated that during 1914 about 30 different mines were worked in the district, employing about 130 men. These were about equally divided during the winter and summer seasons, but about four-fifths of the gold was taken out during the winter, and most of this was won from the deep Hammond River placers. About six mines were operated on Hammond River during the winter and two in summer. A 137-ounce nugget of gold was found on Hammond River. Nolan Creek was the second largest producer, with five plants operating in winter and three in summer. Five mines were operated on Gold Creek in winter and four in summer. There was also productive mining on Myrtle, Emma, Vermont, Linda, Smith, Wild, and other creeks of the district.

Sluicing was somewhat hampered because of low water in midsummer, and hence the gold output was somewhat smaller than was expected. The white population of the entire district is about 250. Mining costs are high. Wages are $6 to $10 a day, with board, which costs from $3 to $4. Supplies are brought from the Yukon up the Koyukuk to Bettles, a distance of about 500 miles, by a steamer which makes from three to five trips each summer. The cost of freight to this point is about $90 a ton. From Bettles supplies are hauled to Nolan on horse scows at a cost of about $140 a ton. The summer freight rate from Nolan to the mines on Nolan Creek is $140 a ton and the winter rate $90 a ton. From Nolan to Hammond River the summer freight rate is $100 a ton and the winter rate $40. The average operator probably pays more than $300 a ton for the freight delivered at his mine. The facts in hand indicate that more than half of the gross value of the total gold output of the district is needed to pay the cost of transportation. These facts are reflected in the cost of some of the supplies. Hay and oats cost $150 a ton, and as a consequence there are but few horses in the district, though some native hay is utilized. Wood costs $12 to $16 a cord delivered on the claim. As high as $350 a ton is paid for the small amount of blacksmith coal used in the district. There is not a wagon road in the district except a few inferior ones built by private enterprise.

Under these conditions it is not a wonder that operators have not been encouraged to undertake any large mining ventures. It has, in fact, been possible to work only the richest ground, and much of that available under present conditions is approaching exhaustion. A few steam hoists and thawing outfits constitute about the only mine equipment, except pick and shovel, used in the entire district. No steam scrapers have been utilized and only one or two small

pumps. There are, however, a few small hydraulic plants used on bench gravels.

The Koyukuk contains much placer ground that could be profitably exploited if operating costs were reduced. There are on Nolan and Hammond creeks deep placers, that can not now be worked because of the underground circulation of water, which can only be handled with pumps. There are other deposits that could probably be mined with steam scrapers and some that could be hydraulicked. Low-grade deposits suitable for dredging are also reported.

Small operations were continued in the Indian River district, lying in the lower Koyukuk basin. It is estimated that six or eight mines were operated during the summer, employing about 25 men, with a gold output of about $25,000.

CHISANA DISTRICT.

The greater number of the stampeders who went to the Chisana district in 1913–14 returned without realizing their expectations in the new camp. Nevertheless, some rich placer ground has been found in this district, though the total bulk of auriferous gravels so far developed is not large. The total gold output from the district in 1914 had a value of about $250,000. It came chiefly from Bonanza Creek, but there was also a considerable output from Little Eldorado and Skookum creeks. Twenty-two mines were operated in the district during the summer of 1914, employing about 325 men. A description of the mineral resources of Chisana district is contained elsewhere in this volume.

CIRCLE PRECINCT.[1]

The Circle precinct includes the Birch Creek district as well as the placers of the Woodchopper Creek and Beaver Creek basins. It is estimated that gold to the value of $225,000 was produced here in 1914, compared with $175,000 in 1913. About 46 mines, employing 80 men, were operated in winter, and 53 plants, employing 140 men, in summer. Nearly three-quarters of the gold produced was taken out in the summer.

Mining in the precinct consisted of a few large operations, employing 15 to 20 men each, all of which were in the Birch Creek district, and many small operations, which averaged only two or three men to each mine. About half the gold produced was taken from the mines on Mammoth and Mastodon creeks. One placer mine was operated on Mastodon Creek in winter and eight in summer. On Mammoth Creek one claim was worked in winter and three in summer. The old dredge that was brought in from Dawson and installed on Mastodon Creek in 1911 was found unfit for further

[1] Prindle, L. M., A geologic reconnaissance of the Circle quadrangle, Alaska: U. S. Geol. Survey Bull. 538, 1913.

service and dismantled. The control of the dredging ground reverted to the owners, and the ground is being worked by two hydraulic plants. There are also two other plants operating on Mastodon Creek, one above and the other below the dredging ground.

On Mammoth Creek a hydraulic plant was operated. The same operators bought a dredge, which was landed at Circle during the summer of 1914. This will be carried over the Government road 40 miles to the mouth of Mammoth Creek. It is hoped that it will be installed in time to operate the full season of 1915. The dredge has buckets holding 3½ cubic feet, close-connected bucket line, 170-horsepower steam engines, and an estimated daily capacity of 2,000 yards. Wood will be used as fuel. The ground on Mammoth Creek is 12 to 16 feet in depth. It is chiefly coarse gravel, not frozen, and is said to be well adapted for dredging. On Miller Creek, a tributary of Mammoth Creek, three plants operated during the summer. Five plants operated on Independence Creek, which joins with Mastodon to form Mammoth Creek. One of these used a 1-yard steam shovel to deliver the gravel to a movable grizzly over portable sluice boxes.

Deadwood Creek was worked by eight to ten small outfits by open-cut methods. Some drift mining also was done on lower Deadwood Creek during the winter. It is proposed to install a hydraulic plant on upper Deadwood Creek next season. Switch Creek, tributary to Deadwood Creek, supported the operation of two drift-mining outfits throughout the summer. A hydraulic plant, intended to work claims Nos. 3 to 6, inclusive, on Switch Creek, was landed at Circle during the summer and is to be installed for operation in 1915.

A single plant operated on Half Dollar Creek, a tributary of Harrison Creek, and another on Eagle Creek, which is tributary to Birch Creek. The Eagle Creek plant has hydraulic equipment and uses water from Independence Creek. This plant uses two to four nozzles, according to the water supply.

The Birch Creek district, one of the oldest on the Yukon, has up to recent years been mined only by very simple methods. A change has now come about in the adoption of dredging and hydraulicking. The construction of a good wagon road from Circle, on the Yukon, to the district has been an important element in bringing about this change and is a good illustration of the quickness with which the mining industry responds to the improvement of conditions of transportation.

In the Woodchopper Creek region about 10 mines were operated and 25 men were employed during the summer of 1914. Ten plants were operated in the winter. Most of these were on Coal Creek, a southerly tributary of the Yukon 60 miles above Circle. Preparations are under way for installing a hydraulic plant on Woodchopper

Creek, water to be conducted from Iron Creek to the mouth of Mineral Creek.

INNOKO DISTRICT.

The Innoko district is estimated to have produced gold to the value of $200,000 in 1914 and $280,000 in 1913. This was produced by 26 mines employing some 88 men. All of this work except a little winter drift mining on Ophir and Little creeks was open-cut work. The producing creeks are Ophir, Spruce, Little, Ganes, and Yankee. Eight plants were operated on Ophir, three on Spruce, eight on Little, three on Ganes, and four on Yankee. Operating costs are high because of the high price paid for supplies.

It is reported that considerable work was done on Cripple Creek, which is located about 30 miles northeast of Ophir. Cripple Creek flows into Colorado Creek, a tributary of the Innoko. The placers are deep and are worked by underground methods. It is reported that five mines were operated on this creek, with a total output of $15,000.

FORTYMILE DISTRICT.

The Fortymile district was the first of the Alaska-Yukon gold fields to be developed. Here placers were discovered in 1886,[1] and since that time the district has produced gold to the value of about $6,100,000. In spite of the inaccessibility of the region in the early days, a considerable number of prospectors reached the scene of the discovery, and the first year of mining yielded probably about $60,000 worth of gold. The annual gold output rapidly increased, so that by 1894 it amounted to $400,000. The output in 1896, the year of the Klondike discovery, was nearly half a million dollars. Since then the output has declined. As in other isolated camps, operating costs are high. Most of the supplies are sledded up Fortymile River at heavy expense.

A remarkable feature is that this placer-gold output has for 28 years practically all come from the same creeks that were discovered in the first few years of mining. The only marked exceptions are the placers of Wade Creek, which were found in 1899.

Most of the gold from the district has been won by the simplest of manual methods, there having been but few attempts at the installation of machinery. The only exceptions were the building of some small dredges in 1907. These were successfully operated until 1913, when for one reason or another they were abandoned or moved. It is difficult to understand why dredging has not been developed on a larger scale, as there are many placers which could be exploited in this way. It is probable, however, that the dredging operations

[1] Prindle, L. M., The Fortymile quadrangle, Yukon-Tanana region, Alaska: U. S. Geol. Survey Bull. 375, p. 34, 1909.

attempted were on too small a scale to assure profitable ventures. There are also extensive bench gravels in the Fortymile district, which give promise of yielding workable placers. The topographic position of some of these deposits and the available water supply[1] are more favorable to hydraulic mining than in most of the other Yukon camps. There is also some possibility of developing water power.[2] Plans have been under consideration for the use of electric power for operating dredges in the district, to be developed at a coal mine in the Canadian Yukon, located at Coal Creek. There is a power plant at this mine, which is 20 miles from the point where Fortymile River crosses the international boundary.

The possibilities of large mining developments are now under investigation, but meanwhile actual mining is on the decrease. In 1914 the value of the gold output from the Fortymile district was about $60,000, compared with $100,000 in 1913. One reason for this decline was that certain claims were under bond with a company which was investigating the possibilities of large developments. Until such developments take place a revival of mining is not to be expected. Nearly all the operations in 1914 were on a small scale, and probably about 25 claims were worked by 75 to 100 men during the summer. Some winter work was done on Wade, Lost Chicken, and Chicken creeks. The winter work on about 10 claims on Wade Creek yielded about $9,000 and the summer work about $7,000. Chicken Creek was one of the largest producers, with an output between $15,000 and $25,000. Some mining was also done on Franklin, Walkers Fork, Squaw, Buckskin, Ingle, and other creeks. About a dozen men were engaged in mining with rockers on the bars of Fortymile River during low stages of water.

Considerable prospecting was done on Mosquito Fork with the view of finding placers for large development. Some dredging ground on Fortymile River near the boundary was also investigated with a view of installation of dredges. Good prospects were found on Texas Creek, a tributary of Fish Creek, which flows into the North Fork of Fortymile River.

EAGLE PRECINCT.

The Eagle precinct includes the gold placers of American Creek and Seventymile River and some smaller streams tributary to the Yukon from the south. The value of the gold output from this region in 1914 is estimated to be $50,000, or about the same as in 1913. About 20 mines were operated during the year, employing about 70 men. There was practically no winter work.

[1] Ellsworth, C. E., and Davenport, R. W., Surface-water supply of the Yukon-Tanana region, Alaska: U. S. Geol. Survey Water-Supply Paper 342, pp. 67–119, 1915.
[2] Idem, pp. 328–329.

Five mines were operated on American Creek in 1914. Three of these employed 6 to 10 men each. About nine plants were in operation on Seventymile River and its tributaries. Much dead work was accomplished in building dams and opening ground with a view to larger operations next year. All the mines are of the open-cut type, and the methods used include ground sluicing, automatic dams, and small hydraulic operations.

A single plant worked on the main Seventymile near the falls. A little "sniping" was done at other points along the river, but such work was of little importance. Systematic prospecting of the low-grade placers of the Seventymile Valley, with a view to installing a dredge, was under way. Single plants operated also on Flume, Crooked, and Nugget creeks. One of the outfits on Barney Creek installed a small hydraulic plant, the only one in the district.

A little prospecting and mining was done on Washington, Sonickson, Fox, Curtis, and Pleasant creeks, but with only small returns. Some prospecting was done on Flat Creek, a tributary of Charley River.

A quartz prospect known as the Caribou ledge, on Flume Creek, has been opened by a 100-foot tunnel, and an arrastre has been installed to test the ore. The ledge is said to have a maximum width of about 8 feet, but no report as to its value has been received.

RAMPART DISTRICT.

The usual small-scale operations were continued in the Rampart district in 1914. About 10 mines were operated during the summer, employing 25 men, and 6 in winter, employing about 10 men. The value of the total gold output was about $30,000.

Hunter Creek led the others in scale of operations and output. Two hydraulic plants, employing four men each, worked on claims Nos. 1 and 19 about Discovery. A little sluicing was done on a group of claims including Nos. 6 to 10 above and also on No. 1 below Discovery. Two mines were worked on Little Minook, the second largest producer.

A few men worked on Slate and Quail creeks, and one man worked alone on Big Minook Creek near its head. The gold recovered on Big Minook consisted chiefly of nuggets weighing from 1 to 3 ounces each.

Considerable dead work was done in preparation for larger operations next year. Two automatic dams were put in on Hoosier Creek. A dredge is to be installed on Minook Creek.

SMALLER YUKON DISTRICTS.

Placer mining in the Chandalar district during 1914 was confined to some small operations on Big, St. Marys, and Squaw creeks.

Three mines were operated, employing 8 to 10 men. No important developments of the auriferous lodes have been reported.

Productive mining operations in the Bonnifield district were about on the same scale as in previous years. It is estimated that about 15 mines were operated and gold was recovered to the value of about $30,000.

There was a little mining on some new placers on tributaries to Healy Creek from the north, mostly by plants employing not over three or four men each. One of these tributaries, Home Creek, is about 8½ miles from Nenana, and another, Alaska Creek, about 5 miles from Nenana. Six men were working on Moon Creek, 6 miles from the mouth. Operations in other parts of the district were the same as in previous years.

No new productive developments took place in the Kantishna district. The gold output in 1914 was estimated to have a value of about $20,000, taken from about ten mines. Both the Kantishna and Bonnifield districts showed the stimulating effects of the proposed railroad. The Government railroad will pass along the western margin of the Bonnifield district and about 60 miles from the Kantishna district. There was, therefore, far more prospecting in both these districts than in previous years. Some lode and placer properties in the Kantishna district were examined by engineers with a view to large developments.

In 1913 some placer gold was found on Wilson Creek, a northerly tributary of the lower Yukon. The district has not been visited by any member of the Survey, but the following notes have been compiled by H. M. Eakin from reliable sources of information:

The Wilson Creek gold-placer district embraces a small area on the north side of Yukon River about 250 miles above its mouth, or 65 miles above Andreafski. Wilson Creek, 10 miles in length, has a broad drainage basin and receives three tributaries from the east and two from the west, all of which are less than 3 miles in length. Named in order going upstream, the tributaries are Wahpooh Creek from the west, Surprise, Disappointment, and Elephant creeks from the east, and King Creek from the west. Wilson Creek enters the Yukon through Polti Slough, which has become navigable in recent years for the largest river steamboats. Six miles above Wilson Creek is Bear Creek, another small northern tributary of the Yukon. Willow Creek, a west tributary of Bear Creek, heads against Disappointment Creek. The area thus drained has a rolling topography of moderate relief. Its valleys are relatively narrow and steep at their heads but broader downstream, and near the Yukon there are extensive flats.

A fair growth of spruce timber covers the lowlands and reaches well up on the slopes and up the valleys to their heads. A small settlement, called Marshall, has been established on the north bank of the Yukon near the mouth of Wilson Creek and is the distributing point of the district.

The bedrock of the Wilson Creek district is reported to consist of schists, greenstones, and intrusive rhyolite dikes. In general the schists and green-

stones are similar to those of Paleozoic metamorphic rocks in other parts of Alaska. Interbedded igneous and sedimentary rocks of probable Mesozoic age crop out along the river both above and below the Wilson Creek locality. The belt of metamorphic rocks is said to extend northward from the Yukon for more than 50 miles.

In the headward parts of all the valleys the alluvial deposits are reported to be shallow. In the Wilson Creek valley at the mouth of Disappointment Creek it is 3 to 12 feet to bedrock. Below this point depths to bedrock increase rapidly, and on Wahpooh Creek, 2½ miles from the Yukon, a 125-foot hole failed to reach bedrock. Where the alluvium is shallow it consists of coarse gravel and bowlders and is unfrozen. The deeper ground is frozen and is composed chiefly of silt overlying a relatively thin stratum of gravel near bedrock.

Considerable mineralization is evident in the greenstone cropping out on the river bank at Marshall and in specimens taken from outcrops on the more inland ridges. The greenstone mentioned contains metallic sulphides, chiefly pyrite and chalcopyrite, and is heavily stained with secondary copper minerals. Specimens taken from an altered rhyolite porphyry dike near the head of Disappointment Creeek carry galena and molybdenite and on assay are said to yield small quantities of gold.

The first discovery of placer gold in the district was made by A. C. Rhode and Andrew Edgar in July, 1913. They reported the find of rim prospects on Wilson Creek near the mouth of Disappointment Creek, going as high as 10 cents to the pan, and before the close of navigation 250 men, on the strength of this report, had gone to the district.

During the winter of 1913–14 prospecting was carried on by sinking shafts and by drilling. Six prospecting boilers and three 4-inch drills were in use. Placers have been reported on Discovery claim, Wilson Creek, and on claim No. 1, Disappointment Creek. Prospects were found also on claims No. 1, No. 1 Bench, and No. 9 above Discovery, Wilson Creek, and on Elephant, Willow, and Happy creeks. Happy Creek is a small north tributary of King Creek, the uppermost tributary of Wilson Creek from the west. The gold is said to be well concentrated on and near bedrock. It occurs for the most part as fine, well-worn shotty particles with only a scattering of small nuggets.

Three plants, employing a total of 14 men, were engaged in mining most of the open season of 1914. Two plants worked Discovery claim and one No. 1 Disappointment. The work is all of open-cut type. The waste is ground-sluiced off, and the gold-bearing gravel is shoveled by hand into sluice boxes made of whipsawed lumber. The production of the entire season is estimated to have a value of $12,000.

Considerable prospecting was done during the summer on a number of claims on several different creeks. About 25 men were so employed. Work of this type will be carried on more extensively during the winter of 1914–15, when it will be possible to investigate the shallow deposits that carry live water during the open season.

KUSKOKWIM BASIN.

The total gold output of the Kuskokwim basin in 1914 had a value of about $110,000, while that of 1913 was probably about $50,000. It is estimated that about 25 plants were operated in 1914, employing about 80 men. In addition to this a large number of men were engaged in prospecting.

The largest mining developments in the Kuskokwin basin are on Tatalina River near the settlement of McGrath, at the mouth of Takotna River. On Candle Creek, a headwater branch of the Tatalina, there is an open-cut mine, the gravels of which are 10 feet deep. A steam bucket hoist is used to elevate the gravels to the sluice box. A churn drill is being used to prospect the deeper placers on the same property, on the lower part of Candle Creek. In all, 22 men are employed here. Three smaller plants, employing 13 men, were operated on Moore Creek.

Mining was also done in the headwater region of Crooked Creek, tributary to the Kuskokwim near Georgetown, and on Bear Creek and some of its tributaries in the Tuluksak basin; on Canyon Creek, flowing into Kwethluk River; on Marvel Creek, of the Aniak River basin; on Rainy and Kapon creeks, confluents of Eek River; and on Butte Creek, a tributary of Aalalik River. All these operations except those in the Tuluksak basin are on a small scale. While auriferous gravels are widely distributed in this region, but few very rich placers have been found. The promise for the future of mining in most of this field seems to lie in exploitation of the placers on a large scale.

Lodes, including deposits carrying gold, copper, and cinnabar, have attracted some attention in the Kuskokwim basin, in spite of the present difficulties of transportation. There has been a small production of quicksilver from the Parks claims, a cinnabar prospect located on the north bank of the Kuskokwim about 21 miles above Georgetown. Other cinnabar deposits in this region have been more or less prospected. These deposits are described elsewhere in this report.

On a copper deposit in the Russian Mountains, about 18 miles northwest of Kolmakof, on the Kuskokwim, a 25-foot shaft has been sunk on a fissure vein, 30 to 60 inches in width, which has been traced some 4,000 feet. The ore contains chalcopyrite, mispickel, pyrite, and stibnite. It is reported by the owner that the ore contains gold, silver, copper, and a trace of nickel. The gold placers and the lodes of the lower Kuskokwim basin are described in some detail elsewhere in this volume.

SEWARD PENINSULA.

Placer mining began on Seward Peninsula in 1898, and the peninsula has produced gold to the total value of $68,442,000, practically all won from the auriferous gravels, though a little lode mining has been done at various times. There has been considerable tin mining and a little coal mining. A little graphite has been produced from deposits located on Seward Peninsula. Iron, galena, tungsten,

copper, and antimony ores have also been found and more or less developed.

The value of the gold output in 1914 was about $2,700,000; that of 1913 was $2,500,000. During the year 39 gold dredges were operated in Seward Peninsula. Of these two were working in the York district on placer ground which carried both gold and tin. In addition to these there was a placer tin dredge in the York district. The 39 gold dredges, which employed about 320 men, were not all worked the full season, for some were not completed in time. It is estimated that dredges recovered gold to the value of $1,450,000. The output was curtailed because the dredging season was unusually short.

It is estimated that 70 placer mines in addition to those worked by dredges were operated on the peninsula in 1914, employing about 500 men and producing gold to the value of $1,250,000. Besides the men engaged in productive mining there were several hundred engaged in prospecting and development work. The total employed in the mining industry during the height of the season was about 1,200. Details in regard to placer mining are presented elsewhere in this volume.

Except for the development of the Lost River tin mine there was little attention paid to lode mining. Developments were continued on some deposits of iron ore 25 miles northwest of Nome, described elsewhere in this volume, and assessment work was done on other lode claims.

KOBUK REGION.

Placer mining in a small way was continued in the Kobuk region during 1914. In the Squirrel River district three claims were worked in the winter and five in the summer, employing 12 to 20 men. Some mining was also done in the Shungnak district. The total output of gold from the Kobuk region in 1914 is estimated to have had a value of about $35,000.

THE FUTURE OF GOLD PLACER MINING IN ALASKA.

By ALFRED H. BROOKS.

INTRODUCTION.

Placer mining in Alaska began by some small operations at Juneau in 1880, although there is an unverified report that some placer mining was done at Sumdum Bay, southeastern Alaska, in 1870–71. It is estimated that during the 35 years since 1880 Alaska's placer mines have produced gold to the value of $175,712,992.

Most of the placer mining in Alaska has been done on a comparatively small scale. During the last six years gold dredges have been extensively used, notably on Seward Peninsula, but the value of the total gold recovered by this method is only $10,100,894, or about 6 per cent of the entire placer production. There has been some hydraulic mining, but the total gold output from this source is probably less than that of the dredges. Much of the deep mining, notably at Fairbanks, has been done on a considerable scale. While no accurate figures are available, it seems probable that over half the gold has been won by the small operations with only very simple equipment. An estimate of the annual placer-gold production is given in the following table:

Value of placer-gold production of Alaska, 1880–1914.

1880–1894	$3,150,000	1902	$5,890,000	1910	$11,894,806
1895	840,000	1903	5,946,067	1911	12,540,000
1896	990,000	1904	6,109,481	1912	11,990,000
1897	690,000	1905	12,124,000	1913	10,680,000
1898	680,000	1906	18,607,000	1914	10,730,000
1899	3,510,000	1907	16,491,000		
1900	5,630,000	1908	15,888,000		175,712,992
1901	4,990,000	1909	16,252,638		

The above table shows that the large annual production began in 1899, the year when the first output was made from the rich beach placers at Nome. The annual gold output from the Nome and other districts of Seward Peninsula reached a maximum in 1906 and since then has greatly decreased. The rich placers at Fairbanks were found in 1903, and by 1905 they yielded a large annual gold output,

which reached its maximum in 1909. Since that year there has been a notable decline in the yearly production. It was the combination of the gold output from the bonanzas at Nome with that from the bonanzas at Fairbanks that resulted in the maximum annual placer-gold production of the Territory in 1906. In more recent years the exploitation of the rich deposits of the Iditarod, Ruby, Koyukuk, Hot Springs, and other smaller districts has gone to swell the annual production of placer gold.

These conditions in the placer-mining industry cause the fluctuation in the value of the annual output. In general, however, the large annual production has been maintained by the mining of rich placers on a small scale rather than by large operations on deposits of lower gold tenor. The depletion of bonanzas in one field has in a measure been offset by the development of new ones in other fields.

The above table indicates a considerable fluctuation in the annual output from placer mining, yet it clearly shows that the industry has during the last decade been on the decline. For several years the output has indeed not varied greatly, but this by no means indicates that under existing economic conditions placer mining can maintain its present status. In some districts, to be sure, such as those of Seward Peninsula, the gold output has probably reached its minimum for many years to come; in others, such as Fairbanks, placer mining is far from being established on a sufficiently permanent basis to give assurance that the present production can long be maintained under present economic conditions. Lode mining, on the other hand, has been on the increase. In 1904 the gold output from lode mining was $3,050,977, in 1914 it was $4,863,028, and the developments now under way give assurance of a very much larger production within the next few years. The decrease in the output of placer gold and the increase in that of lode gold is also illustrated by their ratio to the total production of gold. In 1908 about 80 per cent of the total gold production of Alaska was won from the placers, but this ratio has decreased and in 1914 only 68 per cent of the gold is to be credited to placers.

Although there can be no question of a large increase of lode mining, this does not give assurance of prosperity in all parts of the Territory, for valuable lodes have as yet been developed in relatively few of the placer districts. If, therefore, gravel mining should decline there is no assurance that other profitable mining would develop in all the many placer districts.

Between 5,000 and 6,000 men are engaged in placer mining and prospecting for placers, and nearly a third of the white population of the Territory is directly or indirectly supported by the placer-mining industry. It therefore becomes pertinent to inquire what the future of this industry is to be. Will it continue to decline, or are the known

auriferous gravels sufficient to justify the belief that the industry will hold its own or will increase? There is, of course, always the hope of finding new bonanza deposits such as have in the last decade yielded large returns. Such discoveries, however, can not be forecast, and an estimate of the future of placer mining should take into account only what is now actually known about the extent of the auriferous gravels. In other words, the future of the industry must depend, so far as now can be determined, on the exploitation of auriferous gravels of lower gold tenor than those which in the past have yielded most of the gold.

No one can deny that there are very extensive deposits of auriferous gravels in the Territory. In much of Alaska the gravels of most of the larger streams will yield at least fine colors of gold, and this in itself is evidence of the wide distribution of auriferous alluvium. Because of the lack of systematic prospecting of the gravels carrying small amounts of gold it is difficult to arrive at any definite conclusions about the extent of deposits that can be profitably exploited when cheaper transportation and fuel have reduced the costs of mining. In view of the importance of the subject it has seemed desirable to summarize briefly the data relating to it.

DISTRIBUTION AND EXTENT OF AURIFEROUS GRAVELS.

As placer gold was derived from a bedrock source, the occurrence of auriferous mineralization is the first important element to be considered in determining the distribution of the auriferous gravels. Information in regard to this phase of the subject has been recently set forth [1] and need not here be considered in detail. Much of Alaska falls in the Cordilleran province of North America, a province characterized by geologic conditions favorable to the formation of metalliferous deposits. The areas within which more or less metalliferous mineralization has been found in Alaska are widely distributed. They include southeastern Alaska, a part of the seaward flank of the St. Elias Range, a part of the Copper River and Susitna basins, Prince William Sound, the eastern part of the Iliamna and Clark lakes region, some localities in southwestern Alaska, the two flanks of the Alaska Range, the Yukon-Tanana region, the upper Tanana and White River basins, a part of the Koyukuk basin, and a belt running southward from the Yukon through the Iditarod district into the lower Kuskokwim. Much of Seward Peninsula is gold bearing, and some mineralization has been found in the Kobuk and Noatak basins. Within these areas, which, roughly outlined, comprise between 100,000 and 150,000 square miles, the valuable deposits are, of course, only locally distributed, but they indicate in a general

[1] Brooks, A. H., The mineral deposits of Alaska: U. S. Geol. Survey Bull. 592, pp. 24–26, 1914.

way the zones in which metalliferous mining has taken place or prospects have been found. They thus also serve to indicate roughly the localities where auriferous gravels occur or are likely to be discovered.

It is evident, therefore, that the metalliferous provinces of Alaska are of wide extent and distribution, a fact which augurs well for the future of mining. The provinces thus defined do not, of course, delimit the distribution or extent of the auriferous gravels, though they indicate that there are large areas in which such deposits have been or probably will be found. It should be noted that the mere presence of auriferous mineralization does not necessarily indicate the presence of auriferous gravels, much less that of workable placers. The process of concentration of gold in the placers will not here be discussed, for it has recently been described.[1]

More pertinent to the present inquiry are the known facts in regard to the distribution of placers and auriferous gravels. To discuss this matter adequately it would be necessary to describe all the many placer districts, which would be but to duplicate published data.[2] For present purposes it will suffice to consider briefly these data, presenting, so far as may be, the results in quantitative form.

The maps and reports relating to Alaskan gold fields show the distribution of the known placers and to some extent, where the data are available, also that of the auriferous gravels. This information has been interpreted as indicating that the watercourses in Alaska placer districts where mining is now going on include over 1,000 linear miles of virgin ground which there is good reason to believe contains placer deposits. There are not sufficient facts at hand to justify any estimate of the width or yardage of this supposed pay ground. It may be said, however, that only deposits of sufficient bulk to justify large installations are included in this mileage.

This 1,000 miles does not include the creeks which have in part been worked out, except in such districts as Fairbanks, where it is known that large bodies of virgin ground still remain on the productive creeks. Nor does this mileage include the gravels of any of the large rivers, though some of them are known to be auriferous.

Another possible source of placer gold is in the auriferous gravels that lie outside of the developed mining districts. There are known to be many such occurrences, but the knowledge about them is too scant to justify their inclusion in the gold reserves.

In the absence of tests on the gravels thus defined there are, of course, no accurate quantitative data on their gold content. However, only those deposits have been included whose position relative to

[1] Brooks, A. H., The mineral deposits of Alaska: U. S. Geol. Survey Bull. 592, pp. 28–32.

[2] See list of publications relating to geology and mineral resources of Alaska, at end of this volume.

workable placers gives reasonable assurance that they carry sufficient gold to be profitably exploited by methods now in use in the Territory.

GOLD CONTENTS OF AURIFEROUS GRAVELS.

A gold placer may be defined as a deposit of auriferous alluvium that can be profitably exploited. Whether the deposit is or is not capable of being worked at a profit is a function of mining costs, depending on many factors. It follows that a deposit which under present industrial conditions is simply an auriferous gravel may in the future, by the lowering of mining costs, through the improvement of mining methods or for other reasons, be classed as a gold placer. A good example of this evolution is found in the gold placers now mined by dredges. Before the introduction of this cheap method of exploitation these deposits could not rightly be called placers, though they were known to carry gold, whereas now they are valuable placers, inasmuch as they can be profitably exploited.

It follows, therefore, that the determination of whether or not any given body of auriferous gravels is a placer must take account of the cost of mining. It is generally true that a district in which rich placers occur always contains much larger deposits of auriferous gravels of lower gold tenor, though exceptions to this rule are found in some shallow placers representing local concentrations of gold from a near-by bedrock source. Conversely, the reduction of mining costs in any given district makes available for profitable exploitation the deposits that could not before be included in the gold reserves.

It is therefore of much practical importance to determine the gold contents of the ground which is profitably exploited. Using this information in the comparison of one district with another gives a basis, though only a crude one, to forecast the possible extension of the placer-mining industry in any given district. It need hardly be added that the results are applicable only in general terms and that an actual evaluation of the gold placer reserves can be arrived at only by careful prospecting.

In collecting the statistics of gold production for 1914 special effort was made to ascertain the amount of alluvium handled at each mine. With this purpose, operators were requested to furnish an estimate of yardage as well as gold recovery. Many responded to this request, and as a result it is now possible to determine with a fair degree of accuracy the average gold content of the gravels mined in the different districts and under the various mining methods. It should be noted that the crude methods of recovery in use by many of the small operators involve a considerable loss of gold in the tailings. These data do not, of course, give precise information regarding mining costs, because the results show the costs plus the

profit to the operator. Nevertheless the average of a large number of returns from one district, except in the newer fields, should present an approximation of the gold content that is necessary to profitable exploitation, which is the important thing to this discourse.

It will be well to note that there are several sources of error in these data. One is the fact that many operators do not make accurate record of the amount of gravel handled. Again, there are undoubtedly, as shown from the returns, some placer mines that are worked at a loss, though the operators may not know it, owing to the loose system of bookkeeping they practice.

It is also true that, especially in the newer camps, only the richest placers are being mined, and the average of such operations by no means indicates the lowest gold tenor that can be profitably exploited, even under present conditions. Examples of this are afforded by some of the Alaska dredges, which are working on placer ground carrying as high as $1 or more to the cubic yard, a sum which is, of course, far above operating costs plus a reasonable profit. Attempt has been made to eliminate these sources of error in the data here to be presented.

It has been shown (p. 23) that the estimated average value per cubic yard of the gold-bearing gravels mined each year in Alaska has been gradually reduced from $3.74 in 1908 to $1.26 in 1914. If figures were available for the earlier years it would show a still greater reduction. For example, the average gold recovery per cubic yard in Seward Peninsula for the nine years of mining ending with 1906 was about $5.95,[1] compared with an average recovery of 55 cents per cubic yard for the year 1914.

Though these figures are only approximations, they clearly indicate the fact that gold placers of a much lower tenor than formerly can now be profitably exploited. It is evident that, the mining of low-grade gravels having become economically possible, a much larger placer-gold reserve has become available. In fact, on Seward Peninsula, for example, if profitable mining were possible only on the placers of high-gold tenor, as was formerly the case, mining would now almost have ceased. This change has been brought about largely by improvement of mining methods, for in most of the placer districts the other factors have not greatly changed. At Fairbanks, for example, the unit cost for deep placer mining is probably greater now than it was some years ago. Though wages have remained about the same, supplies cost somewhat more than formerly, and, above all, the price of fuel, wood being used, has increased enormously. Costs can be reduced in two ways—by improvement of mining practice, involving the investment of capital and the employment

[1] Brooks, A. H., The gold placers of parts of Seward Peninsula, Alaska: U. S. Geol. Survey Bull. 328, p. 136, 1908.

of technical skill, and by reduction in the price of supplies and fuel through the construction of railroads and wagon roads.

Estimates of the average gold recovery per cubic yard of alluvium mined in some of the principal placer camps of Alaska during the year 1914 are given in the following table. It should be clearly understood that these figures do not represent mining costs, although the averages for the older districts, as will be shown, bear a close relation to these costs.

Estimated average gold recoveries per cubic yard in some of the Alaska gold placer districts in 1914.

Seward Peninsula:	
Council, Fairhaven, Nome, Port Clarence, Solomon, and Kougarok districts:	
Average	$0.54
Yukon basin:	
Chisana	5.55
Circle	.98
Fairbanks	3.13
Fortymile	2.00
Hot Springs	12.10
Iditarod	1.32
Innoko	4.00
Koyukuk	4.33
Rampart	2.00
Ruby Creek	3.85
Average	2.37
Copper River:	
Nizina, Bremner, and Chistochina districts—	
Average	1.26
Cook Inlet and Susitna basin:	
Kenai, Willow Creek, Valdez Creek, and Yentna districts:	
Average	1.24
General average	1.26

The above table emphasizes some significant facts. For example, the well-organized condition of placer mining in Seward Peninsula is shown by the fact that the average recovery there is only 55 cents to the cubic yard. This, of course, is a reflection of the condition that much of the gold is recovered by dredges. In 1914 the average recovery by these dredges was about 40 cents a cubic yard. This figure is in strong contrast with the recovery of $12.10 a cubic yard for the Hot Springs district, where the operations are chiefly those of deep mining. Hot Springs is a relatively new camp, and at present the gold is mostly taken from bonanza deposits. The relatively small mining operations in the Chisana district, a new and very inaccessible camp, show the high recovery of $5.55 to the cubic

yard. This is to be interpreted as indicating that only high-grade placers can now be mined.

In the older camps the highest recovery, $4.33, is from the Koyukuk district, and this is because the high operating costs, due to the high price of transportation, have limited operations to the richest gravels. The same is true of the Innoko, where the average values are estimated to be about $4, though the returns from the Innoko are rather incomplete, and this figure may be too high. In the Iditarod, on the other hand, dredging has much reduced the average recovery, which in 1914 is estimated to have been $1.32. This is significant of what can be accomplished by the use of machinery, even in camps where operating expenses are high because of the cost of transportation.

The data at hand indicate that the average recovery in the Circle district during 1914 was only 98 cents. This low figure is due to improved methods, for several hydraulic plants were operated and made it possible to mine gravel of relatively low gold tenor. It should be noted that on account of the abundant precipitation during the summer of 1914 in the Circle district the conditions were exceptionally favorable for hydraulic mining and this has undoubtedly increased the average recovery of gold.

The recovery of $2 to the cubic yard in the Fortymile district can probably be interpreted as indicating that in this field mining is at present on the wane and that operators have been forced to exploit the gravels of lesser gold tenor. This district includes large bodies of auriferous gravels, but no large plants have yet been installed. What has been said of the Fortymile district also applies to the Rampart district.

The average gold recovery in the Ruby district during 1914 was $3.85, which is somewhat lower than would be expected in a new camp that is not very accessible. As a matter of fact, the average recovery of the deep mines of the Ruby district is about $7.30 to the cubic yard, indicating that this form of operation is still confined largely to the richest deposits. On the other hand, some large operations in open-cut mining with an average recovery of $2.22 have offset to a certain extent the high returns from deep mines.

Placer-mining operations in the Susitna and Copper River basins and on Kenai Peninsula are not extensive, though they include some large individual plants. In this field the conditions for hydraulic mining being more favorable than in the Yukon basin and on Seward Peninsula that form of mining is more extensively practiced. On the other hand, there has been no dredging in this province. Operating costs have, as a rule, been lower than in the other Alaskan placer districts, largely because the region has been made more accessible by railroads and wagon roads. These facts will account

for the lower recovery of $1.26 to the cubic yard. In other words, they indicate that mining has been possible on gravels of much lower gold content than in the Yukon basin. The average recovery for the entire Yukon basin in 1914 was $3.33.

The comparisons that have been made above of the average gold recovery of different placer districts serve to indicate in a general way the comparative conditions of operations in the different fields, in spite of the fact that most of the gold recoveries here set forth represent averages from more than one method of mining. There is usually sufficient variation in the occurrence of gold in each district to demand different methods of recovery, so that average recoveries may safely be used for comparison. It will be desirable, however, to consider also, so far as the data will permit, the average recoveries made in different districts by each method of mining.

It is natural to look for the lowest gold recoveries in hydraulic mining. Alaska as a whole is not a field for this form of exploitation. In the Yukon basin and on Seward Peninsula the small stream volumes and low gradients are unfavorable to hydraulic mining. There are, of course, exceptions, and the moving of gravel by water under head is practiced in many favorable localities; moreover, many opportunities for this form of mining have not yet been improved. In the Fortymile district there are, for example, bench gravels which should be hydraulicked, and similar deposits are known in other districts. Heavy gravels, which carry some fine gold, occur on both slopes of the Alaska Range. Here there are streams which will furnish water for hydraulic mining. Whether the values are high enough to warrant exploitation can be determined only by systematic prospecting under a competent engineer. These gravels are not included in the above estimates of gold reserves. In the coastal region, including Kenai Peninsula and the Copper and Susitna basins, the conditions are more favorable for hydraulic mining than in other parts of Alaska. Large plants have been installed in several districts and appear to be operated at a profit. There has, however, been no hydraulic mining in Alaska on the scale of that practiced in California.

The average recoveries for hydraulic operations are of little value to the present discussion. Most of the operations that can be classed as true hydraulic mining have worked on ground that carried values from 50 cents a cubic yard upward and furnish little clue as to minimum values which would assure a profit. Two plants report an average recovery as low as 10 to 12 cents a cubic yard, but it is not certain that these plants have been run at a profit. Hydraulic mining can perhaps be eliminated from the present discussion, as but little of the reserve of auriferous gravels here considered is so located as to be available for this method of exploitation.

Much of the gold from Alaska placers is mined by open-cut methods, in which water under head is used in combination with the shovel to bring the gravel to the sluice box. Steam scrapers, hydraulic elevators, and other adjuncts are used in this form of mining. This mixed form of mining is perhaps best exemplified in Seward Peninsula, where the recovered values are reported to be from 30 cents to $1 or more to the cubic yard. Enough of these operations are reported to be mining gravel carrying 60 to 80 cents or less to make it probable that these plants are being operated at a profit.

The recoveries from the mixed form of mining in the Iditarod district average about $1.46 a cubic yard. Four large plants in the Ruby district averaged a recovery of $2.22 a cubic yard. It is unfortunate that the returns from this form of mining in the Fairbanks district are not complete enough to justify presenting an average. In the smaller Yukon camps the returns indicate an average recovery of about $2.

In the districts lying nearer the coast, like Kenai Peninsula and Yentna, the average recovery for the mixed mining is $1 or less to the cubic yard. All these facts go to prove that placers located in the inland regions must, to justify exploitation, carry about twice as much gold as those of Seward Peninsula and other accessible regions.

It has already been stated that the average recovery of the Seward Peninsula dredges is about 40 cents to the cubic yard, which undoubtedly gives a good profit under the average conditions. Only a few dredges have been operated in other parts of Alaska, so there is little basis of comparison. With fuel at a reasonable price, the abundant lignitic coal, and cheaper transportation by railroad, there seems to be no reason why dredging should be more expensive in the Yukon region than in Seward Peninsula. There is every reason to believe, therefore, that dredging will yet be an important industry in the Yukon placer camps.

Deep placer mining, or drift mining, as it is generally called in Alaska, is the most expensive mode of operation. It has been perfected at Fairbanks, where the average cost in 1908, according to Prindle and Katz,[1] was about $3 a cubic yard, not including overhead charges. Since that time operators report that the costs have been increased because of the higher price of supplies and fuel. The average recovery from 25 mines, which sent in complete reports in 1914, was $5.20. As the royalty is usually 20 or 25 per cent, it can be seen that the operations were carried on with no great margin of profit. It is therefore probable that deep gravels averaging less than $5 a cubic yard can not now be mined at a profit in the Fairbanks district.

[1] Prindle, L. M., and Katz., F. J., A geologic reconnaissance of the Fairbanks quadrangle, Alaska: U. S. Geol. Survey Bull. 525, p. 181, 1913.

In the Ruby district during 1914 the average recovery from deep mining was about $7.30 and in the Hot Springs district about $15. Both of these are comparatively new camps, where the operators have not yet been forced to develop the placers of lesser value. Incomplete returns from the Koyukuk district indicate that the average recovery from deep mines is about $7 to the cubic yard. This is one of the old camps in which the cost of operating continues to be high.

SUMMARY AND CONCLUSIONS.

The data set forth above indicate a wide variation in the average gold recovery in the different placer districts. This, with certain exceptions already explained, can be used as a measure of mining costs.

As in nearly every one of these placer districts there is a far larger quantity of auriferous gravels than that constituting the placer deposits workable under present economic conditions, it is safe to conclude that Alaska's reserves of placer gold are by no means approaching exhaustion. If by improvement of the economic conditions the cost of operating the Yukon camps can be reduced to that of the camps on Seward Peninsula, large deposits of auriferous gravels will be available for profitable exploitation. There is no exact measure of the extent or value of these deposits, but that they are present and only await improved conditions of transportation and fuel supply to be classed as workable placers there can be no doubt. The conclusion from this analysis is that given cheaper fuel and transportation there is no reason to believe that placer mining will continue to decline.

TIN MINING IN ALASKA.

By HENRY M. EAKIN.

INTRODUCTION.

The first discovery of stream tin in Alaska was made by the Geological Survey in 1900 on Buhner Creek, in the York district, which occupies the western extremity of Seward Peninsula.[1] This discovery awakened interest in the possibility of finding commercial bodies of tin in this part of Alaska, and in 1901 and 1902 considerable prospecting for stream tin was carried on in this field. The first commercial production of tin ore was made in 1902. From that time until 1911, when the first dredge for recovering tin was installed, the placers were worked only on a relatively small scale. Since 1911 the dredge on Buck Creek has operated successfully each season, and in 1914 two dredges were installed on Anikovik River, for the recovery of gold and tin together.

Lode tin was first discovered at Cape Mountain in July, 1902, by W. C. J. Bartels. The following year Arthur J. Collier and Frank L. Hess, of the Geological Survey, found a tin-bearing lode on Lost River, in the eastern part of the York district.[2] Lode mining has been carried on to a greater or less extent ever since the first discovery. The earliest operations were carried on for several years at the Cape Mountain locality, considerable underground development work being done and a few small shipments made. The ground held by the company was then patented, and the property has since been idle. The Lost River mine had been under development in a small way for several years prior to 1913, when the more extensive operations under the present management were begun.

Stream tin has also been found in different parts of the Yukon basin—on Cleary and other creeks of the Fairbanks district in 1904,[3]

[1] Brooks, A. H., A new occurrence of cassiterite in Alaska: Science, new ser., vol. 13, No. 328, p. 593, 1901.

[2] Collier, A. J., The tin deposits of the York region, Alaska: U. S. Geol. Survey Bull. 229, p. 23, 1904.

[3] Prindle, L. M., A geologic reconnaissance of the Fairbanks quadrangle, Alaska: U. S. Geol. Survey Bull. 525, pp. 81, 90, 1913.

in the Circle[1] and Hot Springs[2] districts, probably, in 1908, and in the Ruby district in 1912.[3] There has, however, been no commercial development in any of these fields except in the Hot Springs district.

The known distribution of tin in Alaska is shown on Plate II. The following table shows the tin production of Alaska up to the close of the year 1914. The figures for the early years are not entirely accurate but are based on the best information available. The selling price of some of the smaller shipments has not been reported, and in such instances the price realized on the chief shipments is assumed for the entire production.

Production of tin in Alaska, 1902–1914.

Year.	Tons of metallic tin.	Value.	Year.	Tons of metallic tin.	Value.
1902	15	$8,000	1910	10	$8,335
1903	25	14,000	1911	61	52,796
1904	14	8,000	1912	130	96,000
1905	6	4,000	1913	69	44,103
1906	34	38,640	1914[a]	104	66,560
1907	22	16,752			
1908	25	15,180		526	330,006
1909	11	7,638			

[a] Preliminary estimate.

Practically all the tin produced in Alaska has been shipped abroad for reduction. The earlier shipments went mainly to Swansea, Wales, but lately a large part of the production has been sent to Singapore.

The tin deposits of the York region have been investigated by a number of different parties of the Geological Survey. The most exhaustive studies are those contained in the earlier report of A. J. Collier and a later publication by Adolph Knopf. The reports dealing primarily with the tin deposits, some of which have already been cited, are as follows:

Brooks, A. H., A new occurrence of cassiterite in Alaska: Science, new ser., vol. 13, No. 328, p. 593, 1901.

Brooks, A. H., An occurrence of stream tin in the York region, Alaska: U. S. Geol. Survey Mineral Resources, 1900, p. 270, 1901.

Collier, A. J., The tin deposits of the York region, Alaska: U. S. Geol. Survey Bull. 229, 1904.

Collier, A. J., Recent developments of Alaska tin deposits: U. S. Geol. Survey Bull. 259, pp. 120–127, 1905.

[1] Johnson, B. L., Mineral resources of Alaska, 1909: U. S. Geol. Survey Bull. 442, pp. 246–250, 1910.

[2] Eakin, H. M., A geologic reconnaissance of a part of the Rampart quadrangle, Alaska: U. S. Geol. Survey Bull. 535, pp. 37–38, 1913.

[3] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, p. 29, 1914.

U.
66°
62°
58°

Hess, F. L., The York tin region: U. S. Geol. Survey Bull. 284, pp. 145–157, 1906.

Knopf, Adolph, Geology of the Seward Peninsula tin deposits, Alaska: U. S. Geol. Survey Bull. 358, 1908.

Hess, F. L., Mineral resources of Alaska, 1911: U. S. Geol. Survey Bull. 520, pp. 89–92, 1912.

The following publications deal mainly with more general geologic topics, but contain incidental references to the occurrence of tin in Alaska:

Brooks, A. H., A reconnaissance of the Cape Nome and adjacent gold fields of Seward Peninsula, Alaska: U. S. Geol. Survey Special Pub., pp. 132–139, 1901.

Collier, A. J., A reconnaissance of the northwestern part of Seward Peninsula, Alaska: U. S. Geol. Survey Prof. Paper 2, pp. 49–51, 1902.

Johnson, B. L., Mineral resources of Alaska, 1909: U. S. Geol. Survey Bull. 442, pp. 246–250, 1910.

Prindle, L. M., A geologic reconnaissance of the Fairbanks quadrangle, Alaska: U. S. Geol. Survey Bull. 525, pp. 81–90, 1913.

Eakin, H. M., A geologic reconnaissance of a part of the Rampart quadrangle, Alaska: U. S. Geol. Survey Bull. 535, pp. 37–38, 1913.

Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, p. 29, 1914.

The growing importance of the tin-mining industry in Alaska led to a reexamination of part of the York district in 1914, and to a similar investigation of the tin deposits of the Hot Springs district. Only a brief time could be devoted to the work, and this paper is, therefore, by no means an exhaustive discussion, even of the deposits which were examined. Much of the material here presented has been compiled from the reports listed above.

The writer desires to acknowledge the courteous hospitality shown to him by the residents of the districts visited, and the assistance in collecting data generally lent by the operators. Special acknowledgment is due to Mr. George Jamme, of Lost River and Seattle; Mr. Walter Johnson, of San Francisco; and Mr. Sylvester Howell, of Tofty.

YORK REGION.

Tin ore in both lode and placer form is broadly distributed in the western part of Seward Peninsula, but commercial development has taken place at only a few localities. (See Pl. III.) Lode properties have been prospected at Ear Mountain, Buck Creek, Cape Mountain, Brooks Mountain, Lost River, and a few other localities of minor importance, but the only productive lode mine at present is that of Lost River. Considerable underground work has been done on the Cape Mountain property, but as the mine has been closed for several years it was not examined by the writer. Placer tin has been produced in commercial quantities from Buck Creek and from Anikovik

and Lost rivers. Placer operations in 1914 were confined to Buck Creek and Anikovik River.

The mining activities of the region in 1914 included the operation of three dredges for all or a part of the season, the preparation of a tract of tin placer ground for the installation of an additional dredge, and the operation of the Lost River lode mine and mill. About 40 men were engaged directly in mining operations—20 men on Buck Creek, 5 on Lost River, and 15 on Anikovik River, where two dredges operated for both tin and gold. About 25 men were also employed temporarily in the construction of the new dredge on Anikovik River. The only winter mining done in the district is at the Lost River mine, where 3 men are employed.

LOST RIVER MINE.

GEOGRAPHY.

Lost River is a small stream that heads in the York Mountains and flows southward into Bering Sea about 10 miles east of Cape York. The mine is located in the valley of Cassiterite Creek, which joins Lost River from the east about 6 miles from the coast. An excellent wagon road leads from the coast to the mine over easy grades.

The waters at the mouth of Lost River are generally icebound from early in November to the last of May. During the other five months of the year they afford a port for shipping similar to that of Nome. Landing is hindered only by southerly or westerly storms, and at such times a safe anchorage is to be had in Port Clarence, 25 miles to the east. As a rule, these storms are not long. Freight charges from Seattle, including lighterage at Lost River, on ordinary merchandise are $12.50 a ton (1914). The return charge on ore is $15 a ton (1914).

GENERAL GEOLOGY.

The general geologic features of the Lost River region have been summarized by Knopf[1] as follows:

> The general geologic features of the region are simple. The bedrock consists of the Port Clarence limestone, dipping northward at an angle of 20°. Near the head of Cassiterite Creek the limestone is intimately banded with argillaceous laminæ and intensely crumpled. Locally, the formation is fractured and brecciated, and shear zones of white marble have been formed.
>
> On Tin Creek, another tributary of Lost River, a small granite boss a third of a mile in diameter is intruded into the limestone. The granite is a medium-grained aggregate of feldspar, quartz (which is partly idiomorphic, smoky, and conspicuous), and scattered foils of biotite. The principal effect of this intru-

[1] Knopf, Adolph, Geology of the Seward Peninsula tin deposits, Alaska: U. S. Geol. Survey Bull. 358, p. 43, 1908.

sion has been to marmarize the surrounding limestone, though locally some large masses of contact-metamorphic minerals have been formed.

A considerable number of vertical quartz porphyry dikes pierce the limestone, but only one has been found extending into the granite area. They are fairly persistent and can be traced for several miles across the country. They are not all strictly contemporaneous intrusions, as certain dikes have been found to intersect each other. The quartz porphyries are light-colored rocks containing small glassy quartz and feldspar crystals embedded in an aphanitic matrix.

A few of the quartz porphyry dikes are highly altered and contain more or less of tin and tungsten minerals. Two dikes of this character, known as the Cassiterite and Ida Bell lodes, are being developed by the Jamme syndicate as the Lost River mine.

CASSITERITE LODE.

The general character and mineralogy of the Cassiterite lode have been described by Knopf[1] as follows:

The principal tin prospects of the region are located on Cassiterite Creek and occur in the quartz porphyry dike known as the Cassiterite lode. This dike is 6 to 10 feet thick and can be traced from the head of Tin Creek in a northwesterly direction to Lost River, a distance of 9,000 feet. Near Lost River the dike rock contains a multitude of angular limestone fragments and is really a limestone breccia cemented by quartz porphyry. The characteristic feature of the Cassiterite lode dike rock, where nonstanniferous, is the abundance of sharply defined quartz phenocrysts embedded in a white aphanitic matrix. Thin sections cut from the least-altered portions of the dike show numerous phenocrysts of quartz, orthoclase, and sodic plagioclase embedded in a cryptocrystalline groundmass. The nonlamellated feldspar is opaque from kaolinization, but the plagioclase is unaltered.

Sporadic crystals of clear and limpid plagioclase lie inclosed in turbid orthoclase phenocrysts. Fluorite is common in the groundmass, and patches of topaz occur also. More highly altered phases of the dike merely show quartz phenocrysts lying scattered in a matrix of scaly white mica, fluorite, and quartz. Along a portion of its course the white quartz porphyry dike has broken through an older dike, a gray feldspar porphyry, which is particularly conspicuous on account of the multitude of dull-white phenocrysts that it contains.

The tin-bearing portion of the dike is 3,000 feet long, but the whole of this length can not be considered ore rock; intermittent barren stretches occur, and the ore is probably localized in irregular shoots. The limestone in the vicinity of the stanniferous portion of the dike is seamed with innumerable veinlets which reticulate the surface of the country rock in every conceivable direction. These vary in thickness from a film's breadth to several inches. An energetic metasomatic alteration has accompanied the [formation of the] veinlets, and cassiterite is locally observed in them, but nothing in the nature of a stanniferous stockwork has been formed.

The tin ore found in the quartz porphyry dike is associated with irregular seams and stringers of quartz and lithia mica. Cassiterite occurs both in the stringers and as an impregnation of the altered dike adjoining the stringers. Where the veinlets are absent the quartz porphyry contains no cassiterite and is hard and barren. Wolframite is commonly associated with the cassiterite,

[1] Knopf, Adolph, op. cit., pp. 49–50.

and, though no actual tests have been made, it is probable that the tungsten content of the lode is as valuable as the tin. Pyrite and arsenopyrite accompany the tin ore, and more rarely sphalerite and galena are found. Locally the dike rock contains some molybdenite. The commonest gangue mineral is fluorite, with zinnwaldite next in order of abundance. Thin sections show also the presence of topaz in radial aggregates. Where alteration has been most intense large drusy masses of cubical fluorite and mica occur, and from such localities magnificent specimens of cassiterite in black splendent crystals have been obtained. The usual type of ore, however, is a soft kaolinized porphyry, stained red with iron oxide and impregnated with cassiterite, wolframite, and sulphides. The dike is intensely and irregularly slickensided, and clay gouge is common. The limestone wall rock, however, is firm and hard. It is considerably impregnated with fluorite, which glows with a greenish light when struck with the pick. Thin sections of wall rock immediately adjacent to the dike show that it consists of fluorite and radial topaz, with some colorless mica. Cassiterite occurs to a small extent in the wall rock in narrow veinlets, 1 inch thick, consisting of divergent columnar topaz. In the vicinity of these veinlets the fluoritized limestone contains patches of coarse fluorspar and rosettes of topaz.

Since 1907 additional development has delineated the form of the Cassiterite lode to better advantage. The maximum width devel-

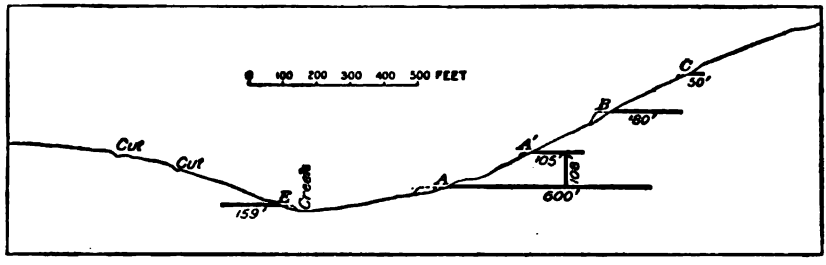


FIGURE 2.—Longitudinal section on Cassiterite lode, showing surface profile and underground developments.

oped is 23 feet, and the average width is estimated at 12 feet, from the evidence afforded by numerous crosscuts along about 1,100 feet of drifts. The extreme limits of development work embrace a horizontal distance of 1,420 feet and a vertical distance of 410 feet above the creek bottom. The indications point to the persistence of the lode in form and character below the creek level, and no special mining difficulties at depth are indicated.

Some strong veins carrying tin crop out 300 feet north of the Cassiterite lode and dip 45° S. The lode itself dips 85° in the same direction, and if these dips persist the veins should meet the lode at a depth of about 300 feet below the creek level.

Developments on the Cassiterite lode in July, 1914, consisted of 1,094 feet of drifts on five levels, besides a number of crosscuts, and an upraise of 108 feet between the first and second levels east, as illustrated in figure 2.

About 2,000 tons of ore taken from the first and second levels east lies on the dump at the portal of the lower adit.

The test mill of the Lost River mine plant has operated for two successive seasons. The dump, containing about 2,000 tons of run-of-mine ore, was sampled by trenching entirely across its center and milling all the ore as it came. The results of the test probably indicate very closely the general tenor of the dump as a whole and of a large body of minable ore blocked out by the developments indicated.

The managers report that about 4 per cent of concentrates were obtained from the ore milled during the two seasons and that no notable variation was observable at any period of operation. The concentrates are very clean and are said to contain an average of 62.31 per cent of metallic tin and 11.08 per cent of metallic tungsten.

IDA BELL LODE.

The Ida Bell lode strikes northeast and intersects the Cassiterite lode at the surface 700 feet west of the creek and 225 feet above creek level. Its dip is approximately 90°. It is wider than the Cassiterite lode, ranging from 25 to 35 feet. Developments on this lode include a 70-foot adit and a 60-foot winze sunk at its extremity.

Like the Cassiterite lode, the Ida Bell is a quartz porphyry dike, but the pronounced alteration of the former is not here duplicated. For the most part the lode consists of firm, slightly altered quartz porphyry intricately traversed by thin, rich veinlets with cassiterite as the only conspicuous valuable mineral. The ore is reported to be of good quality, but owing to its hardness it will require different treatment from that adapted to the Cassiterite lode ores, which are soft. Further development of this part of the mine will await a higher development of the reduction plant.

EQUIPMENT.

The general equipment of the Lost River property includes a small warehouse at the mouth of Lost River; quarters, stable, blacksmith shop, etc., at the mine; a small reduction plant, also at the mine; and the mine equipment. A good limestone road leads from the mine to the beach over easy grades, and with but slight improvement it would be suited for heavy haulage by tractor or team. At present a team and wagon furnish transportation to and from the mine.

Considerable ingenuity has been shown in developing efficient methods of reduction suited to the ores of the Cassiterite lode. Being soft the ores are easily crushed, but an abundance of clay complicates the process of washing.

The ore is first passed through a 6 by 7 inch Dodge crusher, from which it is delivered to a revolving launder that resembles a concrete mixer. From the launder the fine ore is delivered directly to a gyratory mill, and the coarse material is passed through a 3 by 4 inch Case crusher and then goes to the gyratory mill. The crushed ore from the gyratory mill is delivered to an 18 by 60 inch slug mill, from which it passes to a standard Monarch table. The table separates the material into three grades—concentrates, middlings, and tailings. The middlings are returned to the slug mill to be reworked.

The capacity of the plant is 5 tons of ore in 24 hours. Gasoline engines developing 15 horsepower furnish the motive power.

The climate renders it impossible to operate the reduction plant for more than half of the year, but mining is possible at all seasons. The reduction plant has been operated mainly for experimental purposes in developing reduction methods and testing ore for only small parts of the available seasons. The region is barren of timber, so that all fuel, lumber, and mine timbers must be shipped from the States or from other parts of Alaska.

The low grade of the ores mined on Lost River (see p. 87) makes them available only for cheap methods of mining and milling. The ores are easily mined, owing to their softness, which permits the use of augers in preparing holes for blasting. Efficient methods of reduction have been developed, but owing to the small size of the plant the treatment is expensive. It is proposed to replace the test mill by one similar in plan but having a daily capacity of 100 tons of ore.

As methods of reducing the ore have been under investigation each summer at the Lost River plant, methods of recovering the metallic contents of the concentrates have been investigated in winter in Seattle by the same persons. Mr. George Jamme reports the successful separation of tin and tungsten minerals from the concentrates and the successful smelting and refining of metallic tin from the separated ore. Analysis of the refined tin obtained in the Seattle laboratory gave the following result:

	Per cent.
Tin	99.63
Iron	.07
Titanium	.14
Sulphur	None.
Undetermined, probably silver	.16

As progress is gained in mining and reducing the ores in Alaska, it is proposed also to expand from the experimental laboratory to a practical smelter for reducing the concentrates, a service that is not now to be had satisfactorily in the United States.

LODE PROSPECTS.

A large number of lode prospects are held in western Seward Peninsula in the localities named earlier in this report. Most of these prospects have been described by Knopf.[1] Those not operated in 1914 were not examined by the writer and will not receive further attention in the present paper.

The only active tin lode prospecting in this part of the field in 1914 was done in the vicinity of Potato Mountain, at the head of Buck Creek, where several lode claims are held. Only the annual assessment work was done, and nothing new is reported as to the character of the deposits or their promise of economic development.

Much interest has been shown for several years by tin-lode prospectors in the Ear Mountain region, 40 miles northeast of the York district. A large number of properties have been located and development work is in progress on some of them. According to current reports, this section of the tin-bearing region promises the early development of several productive lode mines.

TIN PLACERS.

Placer tin has been produced from Buck Creek and tributaries, from Anikovik River, and from Cassiterite Creek at the locality of the present lode mine. Buck Creek has been productive since 1902. Anikovik River made its first important production in 1914, when two dredges were operated for the recovery of both tin and placer gold. The Cassiterite Creek tin placers were of small extent and were exhausted soon after their discovery, having produced about 20 tons of concentrates.

BUCK CREEK AREA.

GENERAL FEATURES.

Placer tin occurs on Buck Creek for its entire length, about 4 miles, and on Sutter Creek and Left Fork, its principal tributaries. The gravels of Grouse Creek are tin bearing for over a quarter of a mile below the mouth of Buck Creek.

Developments have shown the presence of tin in profitable amounts along the greater length of Buck Creek, in the lower parts of Left Fork and Sutter Creek, and for a considerable distance along Grouse Creek below the mouth of Buck Creek. Actual mining has taken place only on Buck Creek and tributaries.

Knopf[2] has shown that "cassiterite occurs in bedrock in three ways in the Buck Creek area—(1) as an impregnation in quartz porphyry

[1] Knopf, Adolph, Geology of the Seward Peninsula tin deposits, Alaska: U. S. Geol. Survey Bull. 358, 1908.

[2] Idem, p. 33.

dikes, (2) in quartz stringers cutting the slates, and (3) intergrown with arsenopyrite in a gangue of radial actinolite." He ascribes the chief source of the stream tin to the abundant quartz stringers of the Buck Creek area, this being supplemented somewhat by the other forms of bedrock deposits.

Apparently the zone of bedrock that contributed the major portion of the placer tin does not reach eastward to the mouth of Buck Creek. Angular pieces of cassiterite and slightly worn crystals, indicating local derivation, are abundant in the placers only above the vicinity of Sutter Creek. Downstream the stream tin is more and more thoroughly worn; it grades into finer average particles and the placers contain increasing relative amounts of iron minerals.

The erosional history of the Buck Creek area is complicated by an earlier cycle of marine erosion, when broad sea terraces were developed over almost its entire extent, and a later cycle of stream erosion, during which the present depressions were formed. An uplift of the general land mass of about 600 feet intervened between the two cycles. Some concentration of stream tin was effected during the earlier cycle on the surface now represented by the York Plateau, remnants of which occur in the uplands near Potato Mountain, 600 feet above sea level, and elsewhere at about the same elevation. The stream erosion of the later cycle reconcentrated the placers of the old plateau gravels and derived additional concentrates from the bedrock eroded from below this level. The high-level gravels of the plateau surface persist only in small areas about the heads of Buck and Sutter creeks. As they have not been prospected, little can be safely inferred as to their possible value. Direct reconcentrations from them in the gravels of slightly incised headwater streams of Buck and Sutter creeks have been tested and found of high value. Considerable amounts of concentrates are reported to have been obtained from the head of Peluk Creek, and other rich concentrations are reported from similarly situated streams. The worn condition of the concentrates is out of harmony with the slight erosion effected by the creeks from which they were taken, and it seems clear that they represent reconcentrations from the older beach deposits of the plateau surface. The richness of the reconcentrations suggests the possible occurrence of commercial deposits in the plateau gravels.

The downcutting of the streams toward their present positions has apparently been more or less intermittent, and during periods of relative stability the valleys were broadened and the stream courses changed to some extent. The streams that changed their courses failed to carry the concentrations down to lower levels, and local bench placers resulted. Such deposits are reported to occur on

66°
A R
40°
BERING STRAIT
Cape
Prince of Wale
65°
20'
5

Sutter and Grouse creeks, but so far they have not been developed commercially.

DEVELOPED PLACERS.

Commercial tin placers have been developed for about 3¾ miles along Buck Creek and for over a quarter of a mile on Grouse Creek below the mouth of Buck Creek. The development work includes prospecting with the drill, open-cut mining, and dredging. About 1½ miles of the placer ground had been mined out at the close of the season of 1914.

The average depth to bedrock on upper Buck Creek is only 4 feet. Downstream the depth increases slightly, and at the mouth of Sutter Creek and below it is 5 to 6 feet. The width of the placer is 60 to 200 feet. In the upper section the average width is about 100 feet; downstream it is somewhat greater.

The concentrates derived from placer operations contain cassiterite, sundry heavy iron minerals, and a little gold. The average metallic tin content of the concentrates is reported to be about 60 per cent. The tenor is higher upstream and lower downstream, where the iron minerals are relatively more abundant. The gold content is worth only a few dollars a ton, and so far it has not affected the selling price of the product.

OPERATIONS IN 1914.

The only mining operations carried on in the Buck Creek area in 1914 were dredging and preparation of ground for dredging.

The York Dredging Co. operated from July 16 to the end of the season, beginning 1,500 feet below the mouth of Sutter Creek and working downstream. A length of about 6,500 feet above this point had already been dredged. The dredge was built by the Union Construction Co., has open connected buckets holding 2¾ cubic feet, and develops 100 horsepower with distillate engines. Its estimated daily capacity is 800 cubic yards. It was found practical for working only the placers below claim No. 19, where the gravel is over 4 feet deep.

About 1½ miles of placer ground above claim No. 19, owned by the American Tin Co., of San Francisco, was prepared for dredging during the summer. The ground was stripped of muck and vegetation, and drains were cut so that the frozen gravels would be thawed. A shallow-draft dredge will be required to operate in this section of the Buck Creek placers.

ANIKOVIK RIVER.

Placer gold and tin have long been known to occur in the gravels of Anikovik River, but all the early attempts at exploitation by

the relatively expensive manual methods proved unprofitable. In 1914 the American Gold Dredging Co. put two dredges into operation on the lower Anikovik, having tested the ground by drilling the previous year. One of the dredges, formerly on Peluk Creek near Nome, was towed along the coast of Bering Sea intact and was made to dig its own way across the bar into the mouth of the river. It was then shut down for remodeling. The other dredge was new and was installed on an artificial pond a quarter of a mile from the beach. It was completed August 1 and operated continuously for 65 days during the remainder of the open season.

The Anikovik River placers are shallow, ranging generally between 6 and 8 feet in depth. Their materials are chiefly coarse river gravels and cobbles. The bedrock is slate, and locally its surface is uneven, coming close to the surface of the gravels and adding to the difficulties of operation. However, the success of the dredging operations during the season of 1914, when some of the worst "reefs" were encountered, indicates that this condition of the bedrock surface constitutes no fatal obstacle to the undertaking. The chief value of the placers is in their gold content, but sufficient tin is present in them to make a valuable by-product.

The bedrock source of the tin and the history of its concentration in the river placers are probably essentially similar to those of the Buck Creek deposits.

HOT SPRINGS DISTRICT.

GENERAL FEATURES.

Placer tin accompanying placer gold was discovered on Sullivan Creek, in the Hot Springs district, probably in 1908. Gold mining in the district developed rapidly, and as the productive area in the vicinity of Tofty increased it was found that tin and gold were generally associated and that the richer concentrations of the two minerals were generally coincident.

In the earlier mine development no attempt was made to save the tin ore, and as it blocked the riffles and added to the difficulties of saving the gold it was regarded only as a nuisance. During clean-ups more or less of tin concentrates were thrown aside, and the accumulations at the mines were disregarded until 1911, when 1,200 pounds were collected and shipped. The ore was found to be of high quality, and the returns from the small shipment directed attention for the first time to the possible value of tin as a by-product. In 1912 some of the mines made an effort to save more of the concentrates, and 20 tons were shipped. The technique of sluicing for the recovery of tin and gold has been improved, and in 1914 about 48 tons of

concentrates were produced, despite the fact that many operators, including some of the largest, made no recovery. The total waste of tin ore in the tailings of the mines of the district probably amounts to hundreds of tons. With mining operations continuing at their present magnitude the production of tin ore could be greatly increased—perhaps doubled—without additional expense except for the more elaborate system of sluicing required.

The freight rate on tin ore from Hot Springs to Seattle is not definitely known, but it probably does not exceed $55 a ton, which is the tariff on ordinary merchandise (1914). The rates on shipments from Seattle to Singapore in 1914 were approximately $15 a ton.

GEOLOGY.

The known area of occurrence of cassiterite in the Hot Springs district coincides in general with that of the productive gold placers of the Sullivan Creek basin. The general placer zone is about half a mile in maximum width and extends for about 6 miles from upper Cache Creek to Woodchopper Creek. Within this zone are numerous small areas of concentration, as described elsewhere in this volume in connection with the Hot Springs gold placers.

The country rock of the tin-bearing area, as described in an earlier report by the writer,[1] is composed of a series of slates, quartzites, and schists, probably of Mesozoic age. Granitic intrusive rocks occupy two small areas in the same general region, one forming Roughtop Mountain, at the northeastern headwaters of Sullivan Creek, and the other Hot Springs Mountain, at the southeastern headwaters.

The bedded rocks of the area have been strongly metamorphosed. They contain numerous small quartz lenses and stringers and quartz veins that are 20 feet in maximum width. The larger quartz veins where examined are apparently barren of valuable mineralization, but some of the smaller stringers are gold bearing. Gold nuggets more than half quartz are found in some of the placers.

No direct evidence has been discovered as to the form in which the cassiterite occurs in bedrock. Some nuggets appear to have been derived from quartz veins that had been brecciated and recemented with cassiterite; others contain little besides the pure tin mineral. The cassiterite of the placers has been derived from a local source, as is shown by the large size and angularity of some pieces of the ore, and it seems likely that the bedrock source has been in the veins and stringers that cut the metamorphic bedded rocks of the immediate vicinity of the placers.

[1] Eakin, H. M., A geologic reconnaissance of a part of the Rampart quadrangle, Alaska: U. S. Geol. Survey Bull. 535, pp. 20–21, 1913.

PROSPECTING FOR LODE TIN.

The local derivation of the tin ore should be emphasized, on account of the belief current in some quarters that the material of the placers has come from the vicinity of Roughtop Mountain, a belief that has led to much apparently useless prospecting for lode deposits at that locality. The so-called prospects near Roughtop Mountain were examined by the writer in August, 1914, and samples purporting to be high-grade ore were taken. These samples have since been tested chemically for tin, and no trace of the metal was found. The prospect pits are sunk on what appears to be the ordinary country rock in a more highly altered phase near its contact with the intrusive granite. Nothing resembling the tin ore of the placers was found, nor anything that suggested the presence of cassiterite in any other form.

Those interested in prospecting for tin lodes that might have supplied the material of the placers should look to the bedrock in the vicinity of the placers, especially of the placers that contain many angular, slightly worn ore fragments. It seems certain that the bedrock source of much of the tin is to be found between Sullivan Creek and the north margin of its drainage basin west of Quartz Creek. Whether lodes of commercial value occur in this area can be determined only by an examination of the bedrock, a difficult and expensive matter except in the mine workings or along the ridge tops, because of the thick accumulations of alluvium and rock waste.

MINING IN THE JUNEAU REGION.

By HENRY M. EAKIN.

The Juneau gold belt comprises a mainland strip running from Windham Bay northwestward to Lynn Canal at Berners Bay. It contains some mines and prospects south of Juneau, those in the vicinity of Juneau, including Douglas Island, those in the Eagle River and Yankee Basin region, and those in the vicinity of Berners Bay. The geology and mineral resources of this region have been described in full by Spencer [1] and Knopf,[2] but as noteworthy developments have been made in this belt since their investigations were completed, the writer was detailed to visit Juneau and Berners Bay in 1914. Only about ten days was devoted to the work, and it was impossible to visit any except the larger mines and a few of the smaller properties that lay on the route of travel. It is regretted that opportunity was not given to visit the prospects at Taku Harbor and Limestone Inlet, south of Juneau, where some developments are reported. This report is therefore not to be considered an exhaustive statement of the mining developments near Juneau but will serve to record some of the principal features.

The developments near Juneau, because of their magnitude, overshadow the operations in other parts of the gold belt, yet some of these, too, are of importance. The active small-scale mining and milling operations that were conducted a few years ago in the Eagle River and Berners Bay districts have recently experienced a decided falling off, due in part to a failure of some of the properties to meet expectations and in part to consolidations preliminary to operations on a larger scale.

Gold lode mining in this field, already developed on a scale that ranks the Juneau district with the foremost in the industry, is rapidly assuming still greater proportions. The growth is a natural response to a fuller knowledge of the size and character of the ore bodies and the economic possibilities of large-scale operations.

Climatic conditions are favorable to continuous operation. The large size of some of the ore bodies, the physical character of the ores,

[1] Spencer, A. C., The Juneau gold belt Alaska: U. S. Geol. Survey Bull. 287, 1906.

[2] Knopf, Adolph, Geology of the Berners Bay region, Alask. · U. S. Geol. Survey Bu l. 446, 1911; The Eagle River region, southeastern Alaska: U. S. Geol. Survey Bull. 502, 1912.

and a strong topographic relief favor the production of large quantities or ore with a minimum of labor and power. Water power, marine transportation, and a local supply of timber and lumber reduce general expenses to a low point. The extraordinarily low costs of operation make available low-grade ores that under conditions only slightly different would be valueless.

The chief productive mining activity in the Juneau district in 1914 was at the four mines of the Treadwell group, on Douglas Island, where lode mining has been done since 1882 and large-scale operations have been in progress since 1887. The most important development work in progress in 1914 was that of the Alaska-Gastineau, Alaska-Juneau, and Alaska-Ebner mining companies, operating the mines of Silver Bow Basin and Gold Creek, on the mainland a few miles east of Juneau. Prospecting work on a smaller scale was being done at the Salmon Creek mine, near the mouth of Salmon Creek, and at the Alaska Treasure mine, on Douglas Island, about 4 miles southwest of the Treadwell.

The milling operations in the vicinity of Juneau in 1914 were equivalent to the constant operation of about 1,000 stamps. Mining and milling operations combined gave employment to an aggregate of about 2,250 men.

The Treadwell group of mines consists of the Treadwell, Seven Hundred Foot, Mexican, and Ready Bullion mines, on the east side of Douglas Island near the shore of Gastineau Channel, along the strike of a single lead. In the first three mines the lode has been developed continuously for about 3,500 feet. Between the Mexican and Ready Bullion mines is an undeveloped interval of about 2,500 feet.

The ore deposits consist of mineralized dikes of albite diorite intrusive in black slates and belonging to a series of intrusive bodies that appear at intervals along a zone approximately 3,000 feet wide and 3 miles long.[1] The mineralized dikes are cut by reticulating veinlets of quartz and calcite. Both dikes and veinlets may carry metallic sulphides and gold. Although a high gold content may be found in picked specimens, the commercial value of the deposits lies in the wide dissemination of mineralization that renders great bodies of dike material available as ore.

The claims of the Treadwell group were located in 1881. The first mining activity was the recovery of gold from the residual placers over the lode outcrops, and it is reported that $60,000 in all was produced from this source from 1881 to 1883. The first lode development was at the Treadwell. In 1883 a 5-stamp mill that had been erected the previous year was in operation, and several bullion shipments were made. Development continued on a small scale

[1] Spencer, A. C., The Juneau gold belt, Alaska: U. S. Geol. Survey Bull. 287, pp. 95-97, 1906.

until 1887, when a 120-stamp mill was erected. The next year 120 stamps were added to this mill. Between 1893 and 1896 the Mexican, Seven Hundred Foot, and Ready Bullion mines were equipped with mills and a new 300-stamp mill was installed at the Treadwell. These mills aggregated 880 stamps. In 1911, 20 stamps were added to the Seven Hundred Foot mill, bringing the aggregate up to the present total of 900 stamps.

During 1914 all the stamps of the Treadwell group were in practically continuous operation. During this period 1,602,156 tons of ore was crushed, yielding a total output of gold valued at $3,743,944.

Of the total yield, $2,004,527 was recovered as free gold and $1,739,417 was recovered from the sulphide concentrates. The average yield per ton of ore milled was $2.34 and the average operating costs were $1.20, giving a net revenue of $1.14 a ton.

A total of 22,814 feet of development work was done in the four mines, 10,036 feet in ore and 12,778 feet in waste. This work was directed chiefly toward the development of the ore bodies on the lower levels, especially the 2,100-foot level in the Treadwell, the 1,460-foot level in the Mexican, and the 1,570 to 2,200 foot levels in the Ready Bullion and Seven Hundred Foot mines.

The subjoined table shows the value of the gold produced at the Treadwell group of mines since operations were begun:

Value of gold production of Treadwell group of mines, Douglas Island, Alaska.

1882–1884	$10,902	1895	$852,585	1906	$3,085,324
1885	280,479	1896	1,028,691	1907	2,520,000
1886	366,180	1897	1,011,693	1908	3,124,047
1887	476,934	1898	1,010,235	1909	3,534,871
1888	429,889	1899	1,611,857	1910	3,737,498
1889	652,490	1900	2,081,840	1911	4,983,474
1890	160,681	1901	1,665,373	1912	4,080,300
1891	769,765	1902	2,223,373	1913	3,904,066
1892	707,017	1903	2,667,914	1914	3,743,945
1893	694,658	1904	2,845,994		
1894	909,990	1905	3,146,715		58,318,780

The Alaska Treasure Consolidated Mines property is situated on Nevada Creek, Douglas Island, about a mile from the shore of Gastineau Channel and about 4 miles southwest of the Treadwell. The country rock at this locality is a schistose greenstone which shows considerable alteration and mineralization over an area 1 mile wide and 1½ miles long in the direction of the strike of the principal structure. Within the mineralized area is a zone averaging about 90 feet in width and traceable for 2,000 feet on the surface, said to consist largely of commercial ores. A total of 3,650 feet of development work has been done on the property, of which 365 feet is in ore. The ore body is tapped by an adit 2,580 feet in length, 206 feet above

sea level and about 600 feet below the highest outcrop. Part of the development work in ore is credited to operations during 1914, when three men were employed in driving prospecting tunnels.

Prospecting work has been done recently on the Jersey City group of claims and adjoining properties, half a mile west of the Treadwell. Most of it has been surface open-cut work. The bedrock exposed in the cuts is chiefly schistose greenstone interbedded with thin bands of slate. Both greenstone and slate carry more or less of metallic sulphides, which are locally abundant. A shaft and crosscut have been driven on one of the richer spots of sulphide mineralization in a band of slate on the Jersey City property, and encouraging assays are said to have been obtained. The geology of the deposit is closely related to that of the Alaska Treasure property, which is quite different from that of the Treadwell. Should the existence of commercial deposits be demonstrated here, it would greatly enlarge the known area of possible economic development on Douglas Island.

The mining properties of Silver Bow Basin and Gold Creek, on the mainland near Juneau, have entered upon a new era of development under the activities of the Alaska-Gastineau, Alaska-Juneau, and Alaska-Ebner gold-mining companies. Although the deposits held by these companies have been known to exist since practically the first activities in the Juneau region, they had experienced only desultory development on a moderate scale until recently. With the completion of the enormous projects now under way the Juneau district will be placed in the front rank of the gold lode mining centers of the world.

The lode systems on which these properties are situated extend northwestward from Sheep Creek, across Silver Bow Basin and beyond Gold Creek. According to Spencer [1] the principal lodes are near the footwall of a broad band of slates that is bordered on the west by greenstones and on the east by schists. The slaty structure has a general northwesterly strike and dips strongly to the northeast. The slates are intruded by diorite dikes that vary in size and abundance from place to place. The dikes are evidently controlled in strike and dip by the structure of the slates.

The lodes are in general of the stringer-lead type, consisting of zones of the country rock cut by numerous irregular, closely spaced veins of quartz, the whole being more or less thoroughly impregnated with metallic sulphides and small amounts of gold. Considered in fine detail there is considerable variation in the gold tenor of different parts of the same lodes, but the richer bodies are not sufficiently large or persistent to permit their being selectively mined. The mineralization is so generally disseminated in the lodes that the average tenor

[1] Spencer, A. C., op. cit., pp. 23–50.

of the high and low grade materials together is reported to be sufficiently high to render great bodies available as commercial ore. Some of the ore bodies are continuous for more than 100 feet in width and thousands of feet in length and offer a large quantity of ore reaching values of several dollars a ton.

The Alaska Gastineau Gold Mining Co. is developing the properties of the Alaska Gold Mines Co., which comprise mineral lands in the Sheep and Gold creek basins, a mill site at the mouth of Sheep Creek, and a reservoir and water-power site on Salmon Creek. The initial plan of development, as outlined in 1912, when the properties were acquired, contemplated the development of the Perseverance mine to a daily capacity of 6,000 tons, the construction of a mill of like capacity at the mouth of Sheep Creek, and the installation of an 8,000-horsepower hydroelectric plant on Salmon Creek, together with the necessary subsidiary improvements. These plans were being carried rapidly toward completion in 1914. During the year mine development reached the required point, the water-power project was practically completed, and construction on the first 1,500-ton section of the mill was being pushed, with the expectation that it would be ready to operate by the end of the year. Mine development work, not including diamond drilling, has progressed at an average monthly rate of about 3,500 feet. The larger part of this work has been directed to opening the mine preparatory to stoping on the No. 10 and higher levels. On No. 13 level the Sheep Creek adit, 10,000 feet in length, was driven to serve as an ore outlet, completing the transit connection between No. 1 shaft and the mill. All working tunnels as driven were permanently equipped with tracks, electric lights, and telephone lines.

The Salmon Creek water-power project involved the construction of a dam at the lower end of the upper basin and the installation of two hydroelectric generating plants, one a mile below the dam and the other on the shore of Gastineau Channel. The dam was completed in August, 1914. It is of concrete, 700 feet long and 165 feet high, and furnishes a storage reservoir having a capacity of 19,000 acre-feet. When filled the water surface is 1,165 feet above sea level. The two generating plants are similar, each being equipped with two 1,500-kilowatt generating units operating independently The upper plant operates under 600-foot and the lower under 500-foot heads. The upper plant was completed in 1913 and the lower was under construction and expected to be completed in 1914. The two plants are planned to develop 8,000 horsepower. An auxiliary power plant with a capacity of 2,000 horsepower is contemplated for construction on Granite Creek, to furnish extra power during the summer, so that a larger storage of flood waters may be effected in the Salmon Creek reservoir for winter use.

The milling plant under construction is to consist of four units, each with a daily capacity of 1,500 tons. The first unit was well along toward completion in September, 1914, and was expected to be ready for operation before the end of the year. The ore is to be drawn from the chutes into 10-ton cars and hauled in trains of 30 cars to the coarse crushing plant situated on the hillside above the main concentrating plant. The coarse crushed ore is to be dumped into underground storage bins and thence drawn on conveyors to the fine-crushing department. This is 150 feet above the lower floor of the mill, which is 200 feet above sea level, permitting the use of a full system of gravity conveyors in the mill and giving adequate room for the disposal of tailings. The old 30-stamp mill on Sheep Creek has been repaired and is in use as an experimental and ore-testing plant.

Accommodations have been built at the mine and at the mill for the full force of men required to operate at a daily capacity of 6,000 tons. An average of 775 men were employed in all departments during the first eight months of 1914.

The property operated by the Alaska-Juneau Gold Mining Co. is in Silver Bow Basin, on upper Gold Creek, and adjoins those of the Alaska-Gastineau Mines Co. on the north. The extensive development work now in progress on this property was begun in August, 1912. The chief work done so far has consisted of mine development, surface improvements, and the establishment of transit connections between the mine and the mill site on Gastineau Channel just south of Juneau. The mine and mill are connected by a 10,000-foot tramway and a 6,538-foot adit. The adit and a 750-foot upraise to the surface at the mine were the principal achievements in 1913. During 1914 an average of 200 men were employed. The chief activity was directed to running crosscuts and opening out preparatory to stoping. Milling operations were also under way, 50 stamps being used to test ores and methods of treatment. The 50 stamps in operation are a part of the first 150-stamp unit of the permanent mill. The installation of four such units is proposed when mine development has reached a point to justify this equipment.

Power for these operations is obtained from the Treadwell plant. The larger operations contemplated for the future will be supplied from the same source, and it is planned to increase the capacity of the Treadwell power plants to meet this requirement.

The company suggests that the present outlook as regards reserves justifies the expectation that within a few years 12,000 tons of ore will be handled daily by its plants.

The Alaska-Ebner holdings adjoin those of the Alaska-Juneau on the northwest and are divided into two almost equal parts by Gold Creek. This property comprises some of the first quartz loca-

tions in the Juneau region and was one of the first to be developed. A 15-stamp mill had been in operation for several years preceding 1903, and the value of the production to the end of that year was estimated at $600,000. The total underground development at that time comprised about 1,500 feet of tunneling. Development of the property continued on a small scale until August, 1913, when it was bonded by the United States Smelting & Refining Co. This company has undertaken a comprehensive plan of prospecting and development. An average of about 100 men were employed exclusively in the mine. A 3,500-foot adit, undercutting the old Ebner workings by 430 feet, driven from the Last Chance basin, was completed during the summer of 1914. Further development of the ore body by crosscuts was being pushed during the later part of the year. The present operations are considered to be strictly in the nature of prospecting, and the planning and installation of a reduction plant other than the old Ebner mill awaits future showings of the mine.

The Salmon Creek Gold Mining Co. is said to control 25 claims in the vicinity of the mouth of Salmon Creek. The deposits receiving attention consist of four or five separate veins 6 to 20 feet thick. A total of 1,150 feet of development work has been done on the property, 300 feet of it recently by the present operators. A 20-ton tubular mill was in operation and a 15-stamp mill was under construction at the mouth of Salmon Creek. Water power for the plant is developed on Salmon Creek. The work of the company is regarded strictly as prospecting, and its efforts will be chiefly toward mine development until the construction of a larger reduction plant seems justified by the mine showings.

Most of the work in the Eagle River region during 1914 was prospecting. At the Eagle River mine an adit 1,800 feet long and 700 feet below the old workings was driven along a zone of slate in the graywacke series in an attempt to pick up the lode that was lost when the mine was closed several years ago. Several chimneys of ore are said to have been encountered by the adit, one of which is considered an extension of the lost lodes. Active mining and milling was resumed on a small scale September 1 and was continued the rest of the year.

In the Berners Bay region the Kensington and Jualin mines represented the important activities in 1914. At the Kensington mine a 4,700-foot adit was driven at an elevation of 2,018 feet to undercut the Eureka, Kensington, and Johnson lodes. Further work in crosscutting and opening out for stopes is in progress. About 50 men were employed. A 500-ton mill is contemplated for early construction to reduce the ores from these lodes. The project only awaits

financial arrangements, as sufficient ore is said to be blocked out to justify this equipment.

The Jualin mine was being developed on a very substantial scale up to the beginning of the European war, when operations were practically discontinued. The effects of the war were especially felt by the Jualin mine because it was being developed by Belgian capitalists. In addition to the 20 claims already held by the company, the Greek Boy property had been bonded. Since work was resumed under the present management, in July, 1913, an average of about 200 men have been employed. The old Jualin shaft was sunk from 160 to 360 feet, crosscuts and a station were opened on the 300-foot level, and 2,000 feet of a projected 7,500-foot adit was driven. At present 400 horsepower is developed by the company's hydroelectric plant on Johnson Creek. Machinery to develop 600 horsepower additional by the hydroelectric plant and 600 horsepower by Diesel engine, had been ordered and was in transit when operations were reduced. About 20 men are still employed in keeping the mine in condition and in crosscutting to a new ore body discovered by diamond drilling.

The following additional data are not based on the writer's own observations, but were gleaned from what are believed to be reliable sources. The Penn-Alaska Mining Co. is developing some quartz claims near Taku Inlet, south of Juneau. Some stripping was done during the year and a small power plant installed. Some work was done on the Boston claim, at the mouth of Gold Creek, near Juneau. Assessment work was continued on the Peterson group of claims,[1] near Pearl Harbor. Some developments are also reported on the Mitchell and McPherson, Canyon Creek, and Yankee Basin prospects. There are also many other properties in the district on which work was done of equal importance to that recorded, but there is no information about them.[2]

[1] Knopf, Adolph, The Eagle River region, southeastern Alaska: U. S. Geol. Survey Bull. 502, pp. 53–54, 1912.

[2] Attempt is made by the Geological Survey to obtain a full list of mining properties in Alaska on which work is in progress, whether productive or not. The list is, however, far from being complete, and operators will confer a favor by sending each year a brief statement of the work accomplished, even if they do not receive the schedules of production. Information should be sent to division of Alaskan mineral resources, U. S. Geological Survey, Washington, D. C.

MINERAL DEPOSITS OF THE KOTSINA-KUSKULANA DISTRICT, WITH NOTES ON MINING IN CHITINA VALLEY.

By FRED H. MOFFIT.

INTRODUCTION.

The Kotsina-Kuskulana district includes part of the west end of a belt of mineralized rocks extending along the north side of Chitina Valley from the southwest flanks of Mount Wrangell to Nizina River and possibly to the headwaters of Chitina River. (See Pl. IV.) This mineralized belt has already produced considerable amounts of copper and of placer gold and gives promise, as its resources are developed, to continue producing these metals for many years to come.

The Kotsina-Kuskulana district receives its name from the two principal streams that drain it, and owes its present importance to its copper deposits. Copper, however, is not the only mineral resource of the district, for both gold and silver have been found in amounts that may make them of commercial value.

Before the Copper River & Northwestern Railway was completed, in 1911, the Kotsina-Kuskulana district and the rest of Chitina Valley also received supplies and mining equipment by way of Valdez, and during the summer were practically cut off from the outside world, so far as freighting and transportation were concerned, for the cost of carrying freight was prohibitive except in cases of absolute necessity. Since 1911 Cordova has been the distributing point for Chitina Valley, as well as for much of the Copper River valley, and owes such measure of prosperity as it has enjoyed to the interior trade made possible by the railroad. The most important local distributing points along the railroad are Chitina, at the mouth of Chitina River, which is connected by wagon road with the Valdez-Fairbanks road; Strelna, where most of the freight for the Kotsina-Kuskulana district is discharged; and McCarthy, from which supplies are carried into the upper Nizina River valley and across Skolai Pass to White River. Kennicott, the terminus of the railroad, is the point from which the Kennicott-Bonanza ore is shipped, and has more traffic than any other point on the road, yet Strelna and McCarthy are more properly called the distributing points for

Chitina Valley, inasmuch as they serve considerable areas rather than single mining properties.

The building of the railroad contributed greatly to the solution of the transportation problems that prevented the development of this region, but the difficulties are not yet entirely overcome, for each minor district and property has its own problems that must be solved before the full development of the mining resources can be reached. A complete system of transportation for the region will involve the construction of many short railway branches and many thousand feet of aerial tramway.

The development of mining in this region is favored by the presence of both timber and water power. Chitina Valley contains spruce of fair quality in sufficient quantity to supply ordinary local needs for many years, but most probably it will never furnish lumber for export. Abundant water is at hand in many of the mountain streams and will be available for use during much of the year, although on some of the streams it could not be depended on in winter. Data on the water-power resources of the region have been given recently in a report by Ellsworth and Davenport.[1]

Mining in this region will be aided further by the opening of the Bering River coal field, which, because of its nearness (see Pl. IV) and the fact that it contains coking coal, is likely to be of much importance in helping to develop the copper resources. This field can be opened to transportation by a line less than 40 miles long connecting it with the main line of the Copper River & Northwestern Railway 38 miles from Cordova. Surveys for such a road have been made. The construction does not involve unusual difficulties but could not be undertaken while title to coal lands was unobtainable.

Prospecting began in Chitina Valley in 1898 and has continued to the present time. The first metal produced came from the gold placers of Chititu and Dan creeks in 1901 or 1902. These two streams rank next to Slate Creek and the other streams of the Chisna district as regards gold production within the Copper River basin. Commercial shipments of copper ore were begun from the Kennicott-Bonanza mine in 1911, and since then small shipments have been made from a number of other properties. The progress of mining development in the region has been described from time to time in earlier reports of the United States Geological Survey.

There was little change in the general mining situation in Chitina Valley during 1914. Development and assessment work was done on many claims, as in previous years. Shipment of copper ore from the Kennicott-Bonanza was continued with little interruption, and

[1] Ellsworth, C. E., and Davenport, R. W., Preliminary report on a water-power reconnaissance in south-central Alaska: U. S. Geol. Survey Bull. 592, pp. 155–193, 1914.

shipments were also made from the Mother Lode mine. Yet, aside from the Kennicott-Jumbo, no new properties were brought to the producing state, though development work has placed several almost in that condition. Furthermore, little active search for new ore bodies was carried on. Without doubt the depression in the copper market and the difficulty of interesting capitalists in copper-mining ventures were largely the causes of this condition. The season, however, was a favorable one for the placer miners of Dan and Chititu creeks, so that the production of placer gold from these streams and their tributaries in 1914 was greater than for any other season since the early days of mining in the district.

Chititu Creek was visited early in September by S. R. Capps, of the United States Geological Survey, and the notes furnished by him are used in this paper. The Kotsina-Kuskulana copper prospects were visited by J. B. Mertie and the writer, who during the summer completed a detailed geologic map representing an area of about 200 square miles in this district. This work brought to light some new facts concerning the regional geology and the distribution of the ore deposits. These facts will be referred to later.

Plate IV, which represents the lower Copper and Chitina valleys and the Pacific coast of Alaska from a point a short distance east of Cape Yakataga to Prince William Sound, shows the location of most of the better-known copper and gold lode prospects of the region, the gold placers, and the Bering River coal field. The geographic relations of the Chitina Valley copper deposits and the coal fields are illustrated by this map. Reference will be made in this paper, however, to only a part of the prospects of the Chitina Valley.

COPPER.

KOTSINA-KUSKULANA DISTRICT.

A few tons of copper ore for assay, mill tests, and similar purposes have been brought out from the Kotsina-Kuskulana district, but no shipments of commercial ore have been made. Probably no large shipments will be possible in the near future, for none of the copper properties are equipped for mining and handling ore in a commercial way and none of them have any connection with the railroad adequate for the transportation of ore in large quantities. Ore could be sledded from some of the properties to Strelna or other points on the railroad in winter, but the most favorably located deposits, those of Kuskulana Valley, are 15 to 20 miles from the railroad, and the cost would be high. This method of transporting ore from Elliott Creek and the upper Kotsina Valley would be out of the question, owing to the excessive cost.

The geologic mapping done in 1912 and 1914 has modified some of the ideas gained from earlier surveys, particularly that of Schrader and Spencer[1] in 1900, and has made it possible to represent the areal geology more accurately than was possible from the reconnaissance work.[2] Inasmuch as the distribution of copper deposits appears to be controlled chiefly, if not entirely, by a group of rocks commonly known as the Nikolai greenstone, the areas occupied by these rocks are shown on the map (Pl. V), and a brief summary of their geology and that of the associated formations is given. Plate V shows in a generalized way, necessitated by the scale of the map, the areal distribution of the rock formations and the location of those groups of claims on which most work has been done. Five principal formations are represented. At the base of the geologic section is a group of rocks that in previous maps and reports have been called the Nikolai greenstone. These rocks are divided into two parts. The lower part consists prevailingly of dense, hard, water-laid tuffs interbedded with flows of fine-grained black, green, and red basalt. Associated with these rocks are a few beds of limestone in varying stages of silicification, containing Carboniferous fossils. Locally beds of chert, argillite, and slate are found. This lower division has a thickness of several thousand feet. On this prevailingly tuffaceous lower part was poured out a succession of lava flows, in large degree vesicular, and showing a somewhat coarser grain than the basaltic flows included in the tuffs. These upper basalt flows are green in color. Their thickness is probably less than that of the underlying tuffaceous beds, but amounts to several thousand feet. The copper prospects are found mainly in the upper basalt flows, but are not confined to them, for both the underlying tuffaceous beds and the overlying limestone contain copper.

Resting on the Nikolai greenstone is the Upper Triassic Chitistone limestone, a bluish-gray limestone from 100 to 700 feet thick, consisting of one or more massive basal beds without lines of stratification, overlain by thinner beds of the same color and appearance. In places the Chitistone limestone is succeeded by thin beds of limestone that assume a brownish color on weathering and in their upper part are separated by thin shale beds that become thicker and more prominent toward the top of the section till they predominate over the limestone and finally replace it altogether. Probably not less than 4,000 feet of these Triassic thin-bedded limestone and limestone-shale beds overlie the Chitistone limestone on Rock Creek. They are much less developed or are absent on Elliott Creek and the head of Copper Creek, where their place is taken by the black

[1] Schrader, F. C., and Spencer, A. C., The geology and mineral resources of a portion of the Copper River district, Alaska: U. S. Geol. Survey Special Pub., 1901.

[2] A detailed description of the geology and mineral resources of the Kotsina-Kuskulana district, based on the work of 1912 and 1914, will appear in a forthcoming bulletin.

shale that forms the top of this limestone and shale formation or group of formations. No well-marked and easily recognized dividing planes separate the Chitistone from the overlying thin-bedded limestones nor the thin-bedded limestone and shale series from the overlying black shale. The thickness of the Upper Triassic beds is not less than 5,000 feet, and it may be much greater.

The Nikolai greenstone, the Chitistone limestone, and the overlying limestone and shale series were folded, faulted, and intruded by granitic rocks of several types. They were subjected to atmospheric erosion and then were submerged below sea level. Finally there was deposited on them, in late Jurassic time, not less than a thousand feet of coarse conglomerate, grit, and sandstone, with a small amount of limestone, all of which in previous publications have been referred to—the Kennicott formation. Erosion has since removed much of this material, so that the remaining areas are small and scattered, but it is probable that the conglomerate and sandstone beds were irregular in thickness and distribution even when they were first laid down. They are the youngest of the hard-rock formations of the district. The most recent formation includes the unconsolidated Quaternary sands, gravels, and glacial deposits covering the valley floors and strewn over the lower mountain slopes.

The disturbing forces that folded and faulted all the rocks older than the Kennicott formation did not cease to act when the Kennicott was deposited, for it, too, is folded and faulted, though not so severely as the older formations. It is believed that these disturbances, by which the rocks were broken and made permeable to circulating water, in connection with the intrusion of the granite and related igneous rocks, have played an important part in the formation of the copper deposits.

The common copper minerals of the district are bornite, chalcocite, chalcopyrite, malachite, azurite, and native copper. They are associated with epidote, quartz, and calcite. Epidote and quartz, however, are the prevailing gangue minerals, and ordinarily are not accompanied by calcite. A comparison of the mineral content of ores from different parts of the district brings out the fact that the deposits may be grouped in five classes, according to the association of copper minerals in them—deposits that consist chiefly of chalcocite, of bornite and chalcocite, of bornite and chalcopyrite, of chalcopyrite and pyrite, and of native copper. Of these five classes the bornite-chalcocite and bornite-chalcopyrite deposits are the most common. Chalcocite alone is found in only a few places. In several deposits native copper is present, probably as a secondary mineral, in association with chalcocite and with bornite. At one place it is the principal copper mineral present and occurs as a filling in the vesicles of basalt flows and as grains and slugs disseminated through the rock.

The copper minerals of the Kotsina-Kuskulana district occur in the fissures and fracture planes of shear zones and along fault planes. They are also disseminated through the rock adjacent to such zones and faults. The major shear zones and faults show a more or less well-defined parallelism to the principal structural lines of the greenstone, so that outcrops of ore when considered in relation to one another commonly show a similar disposition. Within the shear zones the rock is so crushed and the minor faults and joints so irregular in number and position that no systematic arrangement of ore-bearing fissures was recognized. Well-defined veins are unusual and commonly show the effects of faulting and crushing that took place subsequently to the ore deposition. Some of the basalt flows appear to be particularly favorable for the deposition of copper minerals.

The genesis of the copper ores of the district is not well understood. There can be no doubt that a very great proportion of the copper deposits on the north side of Chitina Valley are in the basalt flows and tuffs of the Nikolai greenstone. In a few places, notably at the Kennicott-Bonanza and its continuation the Mother Lode, at the Kennicott-Jumbo, and at the Westover claim on Dan Creek, the copper minerals are in the Chitistone limestone. One such occurrence, on Copper Creek, is known in the Kotsina-Kuskulana district.

The Nikolai greenstone was subjected to a regional metamorphism that brought about certain widespread chemical alterations, seen particularly in the chloritization and serpentinization of the feldspars and dark minerals of the basalts, and later it underwent other more local alterations, recognized in the quartz and epidote, that are probably connected with the intrusion of granitic rocks into it. These intrusive rocks are less abundant in the greenstone than in the overlying Triassic shales, but are believed to have had an important influence in the formation of the copper deposits.

One of the chief questions concerning the origin of the copper deposits relates to the source of the copper. Was it present in the basalt flows when they solidified, afterward taken into solution by circulating waters during the alteration of the greenstone, and then redeposited in the present ore bodies, or was it introduced from outside sources by the solutions accompanying the intrusive rocks forced into the greenstone? Arguments to support an affirmative answer to each of these questions may be advanced, but the evidence is not yet sufficient on either side to determine the matter.

Most of the copper prospects of the district (see Pl. V) are described in a previous publication[1] of the United States Geological Survey. The present report is concerned chiefly with more recent mining development and does not attempt to give a detailed descrip-

[1] Moffit, F. H., and Maddren, A. G., Mineral resources of the Kotsina-Chitina region, Alaska: U. S. Geol. Survey Bull. 374, pp. 54–74, 1909.

tion of the ore deposits. In describing the properties they will be taken up according to localities.

Assessment work was performed on a large number of claims on Kotsina River and its tributaries, particularly on Kluvesna River and its branches Fall and Mineral creeks, on Granite, Sunshine, Shower, Peacock, Roaring. Rock, Copper, and Elliott creeks.

The prospects on Kotsina River are in the upper valley. Those of the Great Northern Development Co., just below the mouth of Roaring Creek, have received most attention. The copper minerals here are in the tuffaceous part of the Nikolai greenstone and are being prospected by a number of tunnels. The company uses water brought by a ditch from Roaring Creek for developing power and has employed electric drills in its rock work. Mining operations have been partly suspended during the last two years, but assessment work was done on 10 claims in 1914.

The copper prospects of Kluvesna River and its tributaries are in the lower tuffaceous part of the greenstone except those nearest the Kotsina and those just below Fall Creek. The basalt flows near the Chitistone limestone contact west of Kluvesna River contain copper minerals, chiefly chalcopyrite and bornite, in many places, and a group of claims extending parallel to the contact and adjoining it has been staked. The development work consists of two short tunnels that are being driven to strike the limestone-greenstone contact. Near Fall Creek, west of Kluvesna River, about 140 feet of tunnel has been driven in greenstone cut by copper-bearing calcite veins. Native copper and chalcocite are the copper minerals present.

The recent work on Fall Creek consists of two tunnels, one south of Trail Creek and the other high on the mountain between Fall Creek and Kluvesna Glacier. Near Trail Creek the loose surface material on the hill slope was sluiced away to expose the outcrop of chalcocite-bearing quartz veins, and a tunnel was started to cut the veins a short distance below the surface. Native copper and veins of black copper-bearing carbonaceous material are found in the greenstone near by.

Mineral Creek crosses diagonally the strike of a series of tuffaceous beds, cut by granitic intrusive rocks and interstratified with thin light-colored cherty or siliceous beds. The siliceous beds, some of which closely resemble large quartz veins, are faulted and locally are well mineralized. In places, also, mineralized quartz was deposited along the fracture planes. Pyrite and chalcopyrite are the common metallic minerals. A number of short tunnels have been started in the mineralized beds and are being driven in the expectation of developing a workable ore body. One of the claims on Mineral Creek has shown a notable amount of gold associated with the copper. A

tunnel is also being driven in similar beds near the south end of Kluvesna Glacier, northeast of Mineral Creek.

Veins containing copper and a considerable amount of silver cut the basaltic and tuffaceous rocks near the top of the ridge 1¼ miles southwest of Granite Peak. Azurite is conspicuous at a number of shear zones in the vicinity, but at this locality the copper and silver are contained in silver-bearing tetrahedrite, associated with quartz and deposited along joints and fissures. The rocks containing this mineral are much faulted and crushed, with the result that great difficulty is experienced in following the veins. Two short tunnels constitute the development work on the property.

A well-defined fault, striking north-northeast and mineralized with chalcocite, bornite, and a little pyrite in a gangue of quartz, cuts the greenstone on Sunshine Creek. This stream is a tributary of Surprise Creek, which flows into Kotsina River from the north at a point nearly opposite the mouth of Peacock Creek. The fault zone can be traced for more than a mile and evidently includes more than one plane of displacement or minor fault zone. The greenstone along the minor faults is crushed, and its fissures and joints are filled with copper minerals and quartz. Such zones of crushed rock and vein matter have thicknesses ranging from less than 1 foot to 6 or 8 feet. At one place the quartz vein alone is 8 feet thick. It does not form a continuous deposit along the main fissures, but appears as lenses and irregular-shaped masses. Much of the quartz and copper was deposited before the movements along the fault had ended, for the vein matter is crushed and in places slickensided surfaces and gouges are found on both walls of the quartz vein. The claims have been prospected by numerous open cuts and by a tunnel 135 feet long.

Copper deposits are being prospected at a number of places on Roaring Creek. Most of the claims are on the ridge extending north and south from Skyscraper Peak between Roaring and Peacock creeks. The copper deposits are in the upper part of the Nikolai greenstone and consist prevailingly of chalcocite, with which is associated, in a few places, a little native copper. In a general way the mineralized zone parallels the base of the Chitistone limestone exposed in Skyscraper Peak, but lies several hundred feet below it. Although the greenstone is everywhere much jointed, no conspicuous shear zone was observed. It is probable, however, that the fracturing was more extensively developed along the zone indicated by the chalcocite, yet inasmuch as this relation of mineralized greenstone to the limestone and greenstone contact is seen in many parts of the district a suspicion is aroused that the character of the greenstone along this zone had an influence on the deposition of copper. The principal development work on the Skyscraper group of claims

is a tunnel about 100 feet long. Several other shorter tunnels have been started on other parts of the property, but the work of development progresses slowly, for only enough is done each year to fulfill the assessment requirements. With the exception of two or three properties the same statement can be made about the other deposits of the district, and will doubtless remain true till more outside capital can be brought into the region.

The copper prospects west of Roaring Creek are in the lower part of the greenstone. Those that have received most attention are on a spur between two small gulches about half a mile above the forks of the creek. Chalcocite with malachite as an alteration product is associated with quartz and epidote in small fractures in the greenstone. A little native copper, also believed to be an alteration product of the chalcocite, is present in small amounts at one or two outcrops. The development work is represented by two or three short tunnels.

Copper deposits indicated by malachite staining along a shear zone in amygdaloidal basalt occur high on the mountain slope south of Kotsina River and about halfway between Roaring and Rock creeks. The development consists of two short tunnels, but not enough has been done to indicate the character or extent of the deposit. These prospects are near the contact of the upper and lower parts of the Nikolai greenstone, probably in the upper part, but the position of the boundary in this locality is so difficult to trace that the geologic position of the prospects was not fully determined.

Near the contact of the limestone and greenstone on the lower end of Lime Creek, a tributary to Rock Creek, the greenstone is cut by a number of small faults which carry copper minerals. The copper occurs as bornite associated with a small amount of chalcopyrite and is accompanied by quartz and epidote. Small veins or lenses of the bornite cut the greenstone in an irregular way, but most of the ore consists of copper minerals disseminated through the greenstone, though the richest part of the disseminated ore is near the veins. Many of these veins probably represent a replacement of country rock along fracture planes, although they may be in part the material deposited in joint cavities or similar openings. Two tunnels are being driven to prospect the deposits. One of them, on the west side of Lime Creek, is just below the limestone and greenstone contact and follows the strike of the beds. The other, across and a little farther up the creek to the east, is being driven away from the contact. These two tunnels are extended a short distance each year as the assessment work is performed.

All the prospects of Copper Creek except one are in the upper part of the greenstone, and most of them are near the limestone contact. One, the Mullen claim, is in the base of the limestone. The limestone

and greenstone are faulted and shattered, allowing mineral-bearing waters to circulate through them. The limestone along some of the fracture planes is replaced by bornite and chalcopyrite and in part has been oxidized to azurite and malachite, azurite being very prominent. A short tunnel, driven as assessment work, exposes the ore. The other claims on Copper Creek follow the limestone and greenstone contact from the West Fork to the top of the ridge between the East Fork and Pass Creek. One or more of the minerals bornite, chalcopyrite, pyrite, and chalcocite are found in many places along this contact, and a number of open cuts and short tunnels have been made in prospecting the deposits.

The claims on Elliott Creek are owned by the Hubbard-Elliott Copper Co., and extend along the valley of the creek for about 6 miles. Most of them are on the north side of Elliott Creek and cover the ground, including the creek, as far north as the limestone and greenstone contact. A few claims lie on the south side of the valley. A large amount of open-cut work has been done, and many feet of tunnels have been driven on the claims. The most recent work includes the tunnel on the Albert Johnson claim and assessment work on unpatented claims. On September 1, 1914, the main Albert Johnson tunnel had reached a length of nearly 700 feet, not including crosscuts. Since the close of the season, the company reports that the length of the tunnel has been increased to 850 feet. This tunnel is on the southeast side of Deception Creek and is being driven in a northeasterly direction, nearly parallel to the creek, toward the limestone and greenstone contact. It lies wholly in greenstone cut by fault and joint planes, along which copper minerals have been deposited. Bodies of ore consisting of chalcopyrite and bornite were uncovered at several places in this tunnel and its crosscuts. The other work on the claim includes a short tunnel with a winze and crosscuts, farther up the creek and nearer the limestone. This tunnel shows bornite ore and in places considerable amounts of chalcopyrite.

It seems evident that the copper-bearing solutions made their way by devious courses through a shear zone in the greenstone. The bodies of ore are irregular in shape and distribution and without definite boundaries. Most of the ore is a replacement of the greenstone by copper minerals. As the solutions slowly percolated through the openings of the shattered basalt the rock was taken up by them and the copper was left in its place. Nowhere on Elliott Creek are the deposits of the type described as fissure veins.

A tunnel has been started on the Mary Ellen claim, on the south side of Elliott Creek just above the mouth of Rainbow Creek, in the hope of revealing a gold deposit like that of Benito Creek. The shattered greenstone at this place is mineralized with pyrite and a small amount of chalcopyrite. Assays of the weathered surface

material showed considerable gold, which, however, decreased in the less weathered material exposed by the tunnel.

The Great Northern Development Co. owns claims and has done a large amount of work on Clear Creek, tributary to Kuskulana River. Clear Creek follows closely the boundary between the Chitistone limestone and the Nikolai greenstone, which here dip steeply west-southwest. The greenstone on the east side of the creek near its head is intruded by a mass of dark porphyritic igneous rock that appears to be rather generally mineralized in this locality and possibly has been influential in mineralizing the greenstone also. Pyrite and chalcopyrite are disseminated through both the intruded and the intruding rocks. In places they fill minute veinlets, parallel to one another, which represent fractures in a shear zone. In places also they form larger veins along fracture planes, but in general the ore is a low-grade disseminated deposit that will have to be mined as such. Three principal tunnels, with a total length of nearly 5,700 feet, have been driven, and a fourth is now under way. At present active development work is suspended on Clear Creek pending the granting of patents to the property, but the assessment work necessary to hold the claims has been done.

Several claims have been staked on ore of similar nature on the Porcupine Creek side of the same intrusive body and are being prospected by short tunnels.

The copper prospects of Nugget Creek are the property of the Alaska Consolidated Copper Co., which has concentrated its efforts on the Valdez claim, on the point of the hill between Nugget Creek and Kuskulana Glacier. A well-defined east-west fault plane cuts the greenstone and has made possible the deposition of copper minerals, chiefly chalcopyrite and bornite. Large masses of calcite vein filling are associated with the copper minerals, but are not everywhere present, for much of the ore is disseminated through the rock or fills minor cracks and fissures in it. A shaft about 170 feet deep and tunnels aggregating over 1,500 feet constitute the workings. The company also has a tunnel over 400 feet long on the Rarus claim, on the east side of Kuskulana River opposite the mouth of Clear Creek. Half of this tunnel is in silicified limestone, and the remainder is in a dark porphyritic rock containing large crystals of hornblende and in mineralized sandstone. The igneous rock is sheared and contains a large amount of magnetite together with pyrite and chalcopyrite. The sulphide minerals are present in the sandstone also, but magnetite was not seen there. When this property was visited the tunnel had penetrated 15 feet into the sandstone.

Several copper prospects on the mountain between the main forks of the Kuskulana Glacier are held by the Alaska United Copper Exploration Co. A large mass of ore, consisting of a mixture of

granular even-grained chalcocite, bornite, and quartz, was discovered on the mountain side about 1,000 feet above the glacier and has been prospected by several short tunnels and open cuts. No other ore of this nature is known in the district. The proportions of the three minerals are diverse. Chalcocite is the prevailing copper mineral, but in some specimens the bornite equals it in amount. Quartz shows a similar variation, as it may predominate over the copper minerals or may be very subordinate to them. The mass of ore at the surface is in place, but the tunnels have not yet shown its continuation below the surface.

Assessment work was done on a number of other claims east of Kuskulana River, besides that on the Rarus claim already mentioned. They include claims east of Kuskulana Glacier and on a small stream near its lower end and the Berg claims, 3 miles south of Trail Creek. Two or three tunnels have been started on the Berg claims, but development work was interrupted in 1914 on account of financial difficulties, and only the assessment work was performed.

One of the claims adjoining the Rarus is the War Eagle, on the first stream south of Trail Creek. The mineral deposit is near the contact of the quartz porphyry and overlying limestone and sandstone. It consists chiefly of magnetite, but contains iron and copper pyrite. Samples of the ore sent for assay are reported to contain gold and silver in addition to copper.

Copper is found on the head of Chokosna River, where claims have been staked and development work has been carried on in a small way for several years. The property was not visited by the writer, but samples of the ore examined by him showed sulphides of copper and iron in greenstone.

NIZINA DISTRICT.

Mining and development work were carried on at the Kennicott-Bonanza and Kennicott-Jumbo mines throughout the year. In winters previous to that of 1913–14 much delay in ore shipments from Kennicott was caused by snowslides on the railroad, as a result of which all traffic was suspended for weeks at a time. Little delay arose from this cause last winter, however, and ore was hauled to Cordova almost without interruption. Most of this ore was taken from the Kennicott-Bonanza, but a part of it was produced at the Kennicott-Jumbo and hauled over the ice from the mine to the railroad, a distance of nearly 3½ miles. From January 1 to the end of September, 1914, over 4,000 feet of crosscutting, sinking, and raising was done at the Kennicott-Bonanza, and nearly 3,700 feet at the Kennicott-Jumbo. Ore had been developed at the 400-foot level of the Kennicott-Jumbo, and the shaft was being sunk to the 500-foot level. In addition a tramway was constructed for conveying the ore to the railroad. The Kennicott-Jumbo ore is chalcocite, like that of the Kennicott-Bonanza mine.

Development work was continued on the Mother Lode property, about 1¼ miles north-northeast of the Kennicott-Bonanza mine, and on the Westover claim, on Dan Creek. The Mother Lode deposit consists of chalcocite and is situated in the same shear zone as the Kennicott-Bonanza mine but is on the McCarthy Creek side of the ridge, between Kennicott Glacier and McCarthy Creek.

This property was productive in 1914. The company reports the completion up to the close of 1914 of about 1,150 feet of underground work. A tramway 7,000 feet long conveys the ore from the mine to the main camp on McCarthy Creek, from which it is hauled 13 miles on sleds to the railroad at McCarthy. Plans have been made for building a new road down McCarthy Creek in 1915 and for installing a concentrator at the main camp.

Assessment work was done by the Great Northern Development Co. on the claims between the forks of Kennicott Glacier. Such work was also done on claims on Hidden Creek and Lakina River, but details of the operations have not been received.

GOLD.

KOTSINA-KUSKULANA DISTRICT.

Interest in prospecting for gold in the Kotsina-Kuskulana district was aroused two years ago by the finding of a gold-bearing vein on Benito Creek, but although search was made for similar veins in the same neighborhood no others of promise have yet been found. The vein on Benito Creek is a short distance below timber line and consists of quartz and calcite containing chalcopyrite, bornite, pyrite, and free gold. At its outcrop in the creek it is about 2 feet thick. It strikes N. 10° W. and stands nearly vertical or with a high easterly dip. Numerous shallow shafts were sunk and a considerable surface area was ground-sluiced off with water brought by a ditch from Benito Creek, in the endeavor to discover the extent and value of the vein. No other attempt has been made to exploit the vein for the owners are unable to do so and do not care to solicit outside capital. Very beautiful specimens of free gold in quartz were produced by dissolving away the calcite with acid. Apparently the gold is not evenly distributed along the vein, for much of the rock shows no gold to the unaided eye and the specimens of gold mentioned came from only a few places.

NIZINA DISTRICT.

Gold mining in the Nizina district is restricted to the gold placers of Dan and Chititu creeks and to certain of their tributaries, Copper, Rex, and White creeks. Young Creek is not an important gold producer, although considerable ground on it is held by men who expect to prospect it with a view to installing hydraulic mining machinery.

The placer gold credited to Dan Creek comes in part from Copper Creek, one of the two branches of Dan Creek. Several small parties were at work on the gravels of Copper Creek in 1914, but the principal workings and the greatest production of the two streams belong to the lower part of Dan Creek below the canyon. A well-equipped hydraulic plant has been installed there, replacing the one destroyed by the floods of 1912. Water is conveyed to the workings by a flume 650 feet long and a steel pipe line from 15 to 30 inches in diameter and 10,200 feet long. It is delivered to four hydraulic giants, ranging from 3¼ to 5 inches in diameter, at a pressure of 112 pounds. The sluice line is 1,400 feet long. All bowlders over 15 inches in diameter are broken with powder, but smaller ones are carried through the sluice boxes. At the beginning of September 52,000 square feet of bedrock surface had been uncovered, and it was expected that 80,000 feet would be stripped before the season ended. Four frame buildings and a sawmill complete the equipment. The working season in 1914 lasted about 50 days, and during that time 25 men were employed on the property.

A small amount of placer gold is obtained by drifting in the bench gravels on the south side of Dan Creek. The gold-bearing gravels occupy in part the former channel of Dan Creek, but were left as bench gravels when the creek cut its present channel below them. Mining in these gravels has been handicapped by the difficulty of obtaining water for sluicing, but the work has been carried on for a number of years and has yielded a small quantity of gold each season. The owner of this property has added to his yearly gold production through sluicing operations on Copper Creek.

The two hydraulic plants established on Chititu and Rex creeks a number of years ago were in operation in 1914. Weather conditions were favorable, the destructive floods of 1912 and 1913 were not repeated, and sluicing went on without serious interruption, so that a large amount of gravel was moved and an exceptional gold production for these streams resulted.

The lower or larger plant, on Chititu Creek, was employed in mining the creek gravels of claims Nos. 5 and 6, where a cut with a length of 354 yards and an area of 25,144 square yards was made. A total of 102,465 cubic yards of gravel was put through the sluice boxes. The mining season extended from June 8 to September 1, and of this time 67 days, or 79 per cent, was employed in mining. It was found that the gold content of the gravel increased upstream as the cut advanced.

The smaller plant was employed on claim No. 5, on Rex Creek. Less gravel was moved there, but the greater value of that put through the sluice boxes tended to equalize the production.

These two plants require more men for their operation and produce much more gold than all the others in the Chititu drainage area.

They have been employed and probably will be employed for a number of years in mining creek gravels only. It seems probable, however, that the bench gravels of Chititu Creek and its branches may sometime add considerably to the gold production of the district.

The work of one operator on the bench east of Rex Creek is of interest as shedding some light on the extent of gold-bearing gravels in the Chititu Creek basin. Heretofore the producing gravels have been those of the creek. Considerable work was done in prospecting bench gravels during the early days of mining on the stream, but no gold-bearing gravels were found that could be mined profitably under the conditions prevailing at the time. In 1914 L. H. Carvey operated a small hydraulic plant on the east side of Rex Creek above claim No. 3. The bedrock rim of the creek consists of shale and is 55 feet higher than the stream. From 100 to 150 feet of gravel, forming the bench previously mentioned, rests on the shale at this place. The gravel is largely of local origin, consisting for the most part of shale like the country rock but including also material from other sources. It contains fewer large bowlders than the gravel of Chititu Creek, yet bowlders are numerous. All of them would pass through a 30-inch sluice box. The gold is coarse. It is said to be rather evenly distributed throughout the gravel, although the gold content at bedrock is slightly greater than in the upper part of the deposit, and to range from 65 to 75 cents to the cubic yard. One nugget valued at $5.50 was found.

This claim is worked by a small hydraulic plant. Water was conveyed through a steel pipe from 6 to 11 inches in diameter, and was delivered at a pressure of 20 pounds to a hydraulic giant using 2 to 2½-inch nozzles. Unfortunately the water supply is uncertain, for it is subject to the demands made on the stream by the larger plant on Rex Creek, and furthermore a dump that does not interfere with mining on the creek is not available. About 500 feet of timbered tunnels have been driven in the gravel of the bench at various times for the purpose of testing its gold content.

Other placer-mining operations of the Chititu basin are those in the gravels of upper Rex Creek and White Creek. They are less extensive than those previously mentioned, but add to the total production of the district and have helped to make 1914 the most profitable season there in recent years.

Except as previously stated, the gold of Rex Creek comes chiefly from the creek gravels. That from White Creek comes in part from the creek gravels and in part from the benches. An immense amount of gold-bearing bench gravel is present in this vicinity, and probably will receive more attention from miners as the creek gravels become worked out.

AURIFEROUS GRAVELS OF THE NELCHINA-SUSITNA REGION.

By THEODORE CHAPIN.

INTRODUCTION.

This paper is a preliminary statement of the geology and mineral resources of the region which embraces that part of the Susitna Valley lying between the mouth of Maclaren River and Tsusena Creek, most of the drainage area of Nelchina River and its tributaries, the lower parts of the Tazlina and Klutina basins, a part of the foothills of the Chugach and Talkeetna mountains, and a part of the mountain ranges between Susitna River and the Alaska Range. A more complete report, including topographic and geologic maps and sections, is in preparation.

The eastern border of this area was visited in 1898 by F. C. Schrader,[1] and the same year W. C. Mendenhall[2] crossed this region on a reconnaissance trip. W. C. Mendenhall[3] and T. G. Gerdine continued the studies of Copper River in 1902 and mapped the south and west slopes of the Wrangell Mountains and portions of the Alaska Range drained by tributaries of Copper River. In 1906 Adolph Knopf and T. G. Gerdine made geologic and topographic surveys of the headwater regions of Nelchina, Little Nelchina, and Oshetna rivers, and Sidney Paige and R. H. Sargent extended these surveys westward along Talkeetna River to its mouth.[4] In 1910 J. W. Bagley, D. C. Witherspoon, and C. E. Giffin mapped the headwater regions of the Gulkana and Susitna rivers, and F. H. Moffit and B. L. Johnson studied the geology of the same region.[5] Two years later Mr. Moffit and J. E. Pogue extended the geologic surveys to

[1] Schrader, F. C., A reconnaissance of a part of Prince William Sound and the Copper River district, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 341–423, 1900.

[2] Mendenhall, W. C., A reconnaissance from Resurrection Bay to Tanana River, Alaska, in 1898; Idem, pp. 271–340.

[3] Mendenhall, W. C., Geology of the central Copper River region, Alaska: U. S. Geol. Survey Prof. Paper 41, 1905.

[4] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, 1907.

[5] Moffit, F. H., Headwater regions of Gulkana and Susitna rivers, Alaska, with accounts of the Valdez Creek and Chistochina placer districts: U. S. Geol. Survey Bull. 498, 1912.

Broad Pass[1] and J. W. Bagley carried the topographic mapping over the same area. The same year G. C. Martin and J. B. Mertie, jr., studied the geology of the upper Matanuska Valley and the headwater region of Little Nelchina River.[2]

The field work on which this report is based was done by the writer in the summer of 1914 while attached as geologist to a topographic party under the leadership of J. W. Bagley, topographic engineer. The purpose of the work was to connect these former topographic and geologic surveys and carry the work westward. Mr. Bagley connected his own work of 1913 with that of D. C. Witherspoon east of Susitna River and with that of R. H. Sargent and T. G. Gerdine in the Talkeetna Mountains and Nelchina and Copper River regions. The accompanying sketch map (Pl. VI) was prepared by Mr. Bagley and the writer in advance of the topographic and geologic maps now in course of preparation. Field work commenced June 25 at Albert Creek, a branch of Crooked Creek, and closed October 10 at Willow Creek, tributary to Copper River.

Fine colors of alluvial gold may be washed from nearly every stream in this region. Although this fact has been known to prospectors for some time, previous to 1913 gold had not been found in quantity sufficient to be mined profitably or even to encourage prospecting. A fresh impetus, however, was recently given to prospecting in the Nelchina region by the report of a rich find on Albert Creek, one of the branches of Crooked Creek, itself a tributary of Little Nelchina River, and during the open season of 1914 about 400 men were working on the tributaries of Little Nelchina and Oshetna rivers. Gold was found on a number of the creeks near by, but for the most part the results of the season's work were discouraging and few men stayed in the district during the winter. Prospecting has not yet been exhaustive enough, however, to determine adequately the mineral value of the region.

GEOGRAPHY.

SURFACE FEATURES.

The dominant topographic forms bear evidence of the intense glaciation to which the region has been subjected. Three distinct types of topography are represented by the débris-filled lowland with characterless forms, the rounded foothill areas with ice-scoured

[1] Moffit, F. H., Preliminary report on the Broad Pass Region: U. S. Geol. Survey Bull. 592, pp. 301–305, 1914; The Broad Pass region, Alaska: U. S. Geol. Survey Bull. 608, in press.

[2] Martin, G. C., and Mertie, J. B., jr., Mineral resources of the upper Matanuska and Nelchina valleys: U. S. Geol. Survey Bull. 592, pp. 273–299, 1914; Geology of the upper Matanuska Valley, Alaska; U. S. Geol. Survey Bulletin in preparation.

knobs and ridges, and the rugged mountains with numerous cirques. These types, although diverse, are all characteristic of a profoundly glaciated region and are varied expressions of glacial action. Although divisible into smaller topographic units this region falls naturally into four physical divisions, comprising an extensive lowland and, around its borders, three isolated mountain provinces of diverse character—parts of the Talkeetna and Chugach mountains and the rugged ranges lying between Susitna River and the Alaska Range.

The most prominent of these divisions is the lowland province, a broad basin extending the length of the area mapped and including portions of the valleys of Susitna and Copper rivers and the low divide that separates them. This province is floored with glacial silts and gravels that form part of an extensive gravel sheet reaching from Mentasta Pass and the headwaters of Chitina River to Cook Inlet. It is of late geologic age, and its glacial origin is evident from its poorly drained, lake-dotted surface and the character of its deposits. It has a rolling, nearly level surface broken by gravel ridges and sharp canyon-like stream valleys. The drainage is young and undeveloped. The streams have cut into the gravels in V-shaped troughs, and the interstream areas contain ponds and swamps with no apparent outlets.

The lowland province is bordered on the southwest by the Chugach and Talkeetna mountains. The Chugach Mountains form a complex belt 50 to 60 miles wide that extends from Mount St. Elias to Kenai Peninsula in a course roughly parallel to the coast. Their peaks reach elevations of 8,000 to 10,000 feet.[1] East of Tahneta Pass the bold front of these mountains rises abruptly from the gravel lowland, flanked in places by the outlying foothills, the only portion of the Chugach Mountains included within the area here mapped.

The Talkeetna Mountains are separated from the Chugach Mountains by Tahneta Pass and Matanuska Valley. They form a rudely circular mass, with no definite trend line. They are rugged in outline, ranging in general elevation from 5,000 to 6,000 feet, though individual peaks are 8,000 to 9,000 feet high. On the south they rise abruptly from the floor of Matanuska Valley. On the north the low, rounded, flat-topped foothills of this range are carved from an extensive peneplain, which dips gently to the north and is abruptly terminated by the depressed trough that is now covered by the gravels of the lowland province. The foothill area is marked by sharp canyon-like valleys that have been widened and deepened by glacial erosion.

[1] Brooks, A. H., Geography and geology of Alaska: U. S. Geol. Survey Prof. Paper 45, p. 30, 1906.

Northwest of the lowland province, between the Alaska Range and Susitna River, is a tract of rugged mountains, the crests of whose ridges, ranging in elevation from 5,000 to 7,000 feet, form the watershed between the Susitna and the southern tributaries of the Nenana. This mountain mass is made up of several ranges, whose general trend is about parallel to that of the Alaska Range. Within the area mapped they trend about east. To the west they bear toward the southwest, following the general direction of Susitna River. They form a part of a crescentic mountain mass that extends more or less continuously from the vicinity of Gulkana Lake to the junction of Susitna and Chulitna rivers. The valleys are straight, with truncated spurs, oversteepened walls, and hanging valleys. The higher parts contain numerous cirques, in some of which are small active glaciers and in others the heavy accumulations of rock débris that have the form of glacial flowage and are termed "rock glaciers," which are considered to be descended from true glaciers that formerly occupied the cirques. The rugged topography is due in large part to the modifying influence of glacial erosion, which was controlled essentially by the drainage existing at the time of the glaciation.

The drainage of the region is all tributary to Copper and Susitna rivers. Only a small part of Copper River lies within the area mapped, but this part receives several large tributaries that drain the Talkeetna and Chugach mountains. Klutina River heads in Klutina Glacier and flows through Klutina Lake, a body of water 22 miles long. Below the lake the river occupies a recent gorge cut in glacial deposits for about 25 miles to its mouth.

Tazlina River is similar in many respects to the Klutina. Its course lies through Tazlina Lake, which it enters a short distance from its source in Tazlina Glacier. From the lower end of the lake the river flows for 30 miles in a winding course through a deep gravel gorge and enters Copper River 9 miles above the mouth of the Klutina. Nelchina River is tributary to Tazlina Lake. Its south fork, generally regarded as the main fork of the river, issues from Nelchina Glacier. Its main confluent is Little Nelchina River, which, with its tributaries, Crooked and Flat creeks, rises in the Talkeetna Mountains. Mendeltna Creek, the outlet of Old Man, Benzemina, and other lakes, enters Tazlina Lake half a mile below the mouth of Nelchina River. Tolsona and Moose creeks, the principal direct tributaries of Tazlina River, enter from the north and drain flat lowland areas.

The watershed separating the Copper and Susitna drainage basins is poorly defined. It lies on a broad interstream area dotted with swamps and lakes, and the direction in which many of these drain is doubtful. Susitna River and its tributaries drain the western

part of the region. Tyone River issues from a large lake, and after receiving Tyone Creek, a large tributary, locally known as Little Tyone, that rises in the Talkeetna Mountains, enters Susitna River near the "big bend." East of Tyone River are Oshetna River, with its two tributaries, Little Oshetna and Black rivers, and Kosina River. The main tributaries entering the Susitna from the north, named in order from east to west, are Coal, Watana, Deadman, and Tsusena creeks.

POPULATION.

Copper Center, the principal settlement of this region, is situated at the confluence of Copper and Klutina rivers, 101 miles north of Valdez, on the Fairbanks-Valdez Government road, and may be reached from Cordova by rail to Chitina, a distance of 131 miles, and thence by wagon for 50 miles, or by wagon road direct from Valdez. Copper Center is a distributing point for the Nelchina, upper Susitna, Gulkana, and Chistochina regions. A post office, a Government telegraph station, and a Government school for the natives are located here.

Nelchina is a small settlement of 15 or 20 cabins, at the mouth of Crooked Creek. It is the seat of the Nelchina recording precinct and the general headquarters of the neighboring region. Aside from these two settlements the white population of the region is confined to the road houses along the Government road and the transient prospectors and miners.

The Indian population is small. Cabins and camps on Klutina and Tazlina lakes, on Susitna River, and in other places are temporarily used by natives on hunting and fishing expeditions, but aside from a few natives scattered over the region the permanent Indian population is confined to Copper Center.

ROUTES OF TRAVEL.

The Nelchina region may be reached either by way of Knik or by way of Copper Center from Cordova or Valdez. The route from Copper Center follows the wagon road for 10 miles to a point half a mile north of Simpson's road house, and thence goes by a trail along the north bank of Tazlina River and Tazlina Lake to the mouth of Mendeltna Creek. From this point the trail takes a northwesterly direction to Little Nelchina River, and then follows that stream to Nelchina, at the mouth of Crooked Creek. This is a winter trail, and winds around somewhat, to take advantage of several large lakes. For summer travel it is in places very swampy and is passable for horses with difficulty. The distance from Copper Center to Nelchina is about 90 miles.

The Knik route goes by trail up the Matanuska Valley to Chickaloon, from which several possible routes lead to the Nelchina-Susitna region. One follows the Matanuska around the east end of Sheep Mountain, goes up Squaw Creek, and crosses a low divide to the head of Crooked Creek. Another route is the Hicks Creek trail, by way of Billy Creek to the head of Little Nelchina River, or by way of Alfred Creek to the head of Albert Creek. Susitna River may be reached by way of Chickaloon and Talkeetna rivers to low passes at the headwaters of Kosina Creek, a tributary of the Susitna.

Supplies for this region are taken in during the winter from both Knik and Copper Center; but, as Knik is not an open port during the winter, freight from the outside usually goes by way of Copper Center from either Chitina or Valdez. The distance from Albert Creek to Knik is about 106 miles.

This region will be more accessible when the proposed Government railroad is constructed along Susitna River through Broad Pass to the Tanana and the branch line up the Matanuska to the coal field. When the coal-field branch of the proposed railroad is built to Chickaloon, Albert Creek may be reached by an overland journey of 50 miles.

CLIMATE.

The climate is characteristic of the district lying behind the coastal barriers. The rainfall is a medium between the excessive precipitation of the coast and the semiaridity of the interior. The summers are warm, but sudden changes of temperature are not uncommon and may be accompanied with a heavy frost or light fall of snow at any time during the summer. The winters are cold, but the snowfall is not heavy. The open season for placer mining lasts from May until October, varying somewhat from year to year and depending on the elevation of the region. Ice suitable for winter sledding usually forms in November and lasts until March or April.

VEGETATION.

Spruce covers the lowland area to an elevation governed somewhat by local conditions but ranging from 2,500 to 3,000 feet. The quality varies considerably, from the scrubby growth covering the poorly drained swampy areas to trees 2½ feet in diameter, which are occasionally found in favored localities. Most of the timber is ample in size and quantity for building and mining purposes.

Birch, of which there are several varieties, is less abundant than spruce. Cottonwood, willow, and quaking asp are found at elevations higher than spruce, and in many localities furnish the only available firewood. Alder is not abundant.

Bunch grass and redtop grow luxuriantly in places but are not plentiful, so that it is not always easy for the traveler to find forage. A substitute for these grasses is a rank black-seeded swamp grass that horses will eat, though they do not relish it. A little grass appears about the 1st of June, but can not be depended upon until the middle of the month. Horse feed lasts until the time of heavy frosts, which varies from early in September to the 1st of October, depending on the season and location. After other grasses are gone a "pea vine," which grows along river bars and dry benches, is sometimes available.

GAME.

Caribou are the most plentiful large game of the Susitna region. Moose also may be found, but are more common in the low country and around Klutina and Tazlina lakes. A few sheep live in the Talkeetna Mountains and the ranges north of Susitna River. Brown bear are plentiful. Ptarmigan are found throughout the region and spruce grouse in places. Ducks, geese, and other water fowls spend the summer in the streams and lakes, but leave in the fall. In the Susitna drainage basin the clear-water streams abound in grayling, and there are also several kinds of trout, including a very large lake trout. Salmon are plentiful along Copper River and its tributaries, but are not found in the upper Susitna.

GENERAL GEOLOGY.

The geologic formations of the Nelchina-Susitna region comprises several series of lava flows and intrusive rocks, in part altered to greenstone, and a number of sedimentary formations that have been more or less metamorphosed. Both the lavas and the sediments have been invaded by large masses of granitic and dioritic rock. The area has been profoundly affected by glaciation, and is mantled by glacial deposits. The general distribution of the geologic formations is shown on Plate VI.

The oldest rocks recognized are basaltic greenstones, with associated schists and altered sediments, overlain by a great thickness of amygdaloidal basaltic and andesitic lavas. Outcrops of these rocks occur on Stuck Mountain, in the vicinity of Klutina Lake, on Lone Butte and other low buttes near Susitna River, on the round-topped hills south of Maclaren River, and on Watana Creek. The lavas are probably of Triassic age, and the greenstones and schists are evidently older.

The lava flows and associated tuffs on Oshetna River may be the extension of a large mass of similar rocks in the Talkeetna Mountains whose age has been determined as Lower Jurassic. The lavas are composed of andesites, rhyolites, and associated tuffs, in part

INA-SUSITNA RE

altered to greenstone. A complex series of lava flows on Tsusena Creek and the head of Jack River includes rhyolite, andesite, and possibly more basic rocks and contains tuffs, breccias, and thin beds of conglomerate. The rocks are fresh looking and appear to be of recent age, but are fractured and intruded by granite. They are provisionally correlated with Tertiary lavas and associated breccias and tuffs that cap the high peaks at the heads of Alfred and Albert creeks.

Sediments that include beds of Middle and Upper Jurassic and Cretaceous age occur in the headwater region of Little Nelchina River, Tyone Creek, and Oshetna River. These sediments, composed of conglomerate, sandstone, shale, and limestone, unconformably overlie the Lower Jurassic volcanic rocks.

The field term "granite" is conveniently applied to a number of granitic rocks which include, besides granite, dioritic and monzonitic varieties. A large batholith of quartz diorite extends northward from the Talkeetna Mountains near the head of Oshetna River to Susitna River, where it is concealed by gravels, and north of the river smaller masses occur. It is a fine-grained rock, composed essentially of feldspar and hornblende, with varying but subordinate amounts of quartz and accessory mica. From place to place it exhibits considerable variation in texture, becoming schistose with the development of considerable black mica. Diorite gneiss and granite are less abundant. Basic dikes have intruded both the granite and the lavas. The age of the quartz diorite intrusion is believed to be Middle Jurassic, but some of the associated intrusives are Tertiary.

MINERAL RESOURCES.

GENERAL FEATURES.

Auriferous gravels constitute the only mineral resource that is now attracting attention in the Nelchina-Susitna region. Though widely distributed, they are as yet of little economic importance. They have been found in encouraging amount in only a small area, confined to the tributaries of Little Nelchina River, Tyone Creek, and Oshetna River, and so far but little gold has been recovered from them. (See fig. 3.)

The prominent features of the occurrence of the alluvial gold are its widespread distribution and, with one notable exception, the apparent lack of concentration. Fine gold occurs in the glacial gravel which covers the region, and colors may be found even on the hilltops, where no concentration has taken place. The alluvial gold is distributed throughout the vertical section to bedrock. Even the stream gravels lack definite pay streaks, as if there had been but little lateral or vertical concentration since their deposition.

SOURCE OF THE GOLD.

These features indicate a glacial origin for most of the gold. The glacial source of the gravels has been pointed out, and it is evident from the widespread distribution of the alluvial gold throughout the gravels and its lack of concentration that it also was glacially transported. Its bedrock source is not clear. The glacial débris was derived from various sources and contains an abundance of rocks foreign to this region, which were evidently moved a great distance.

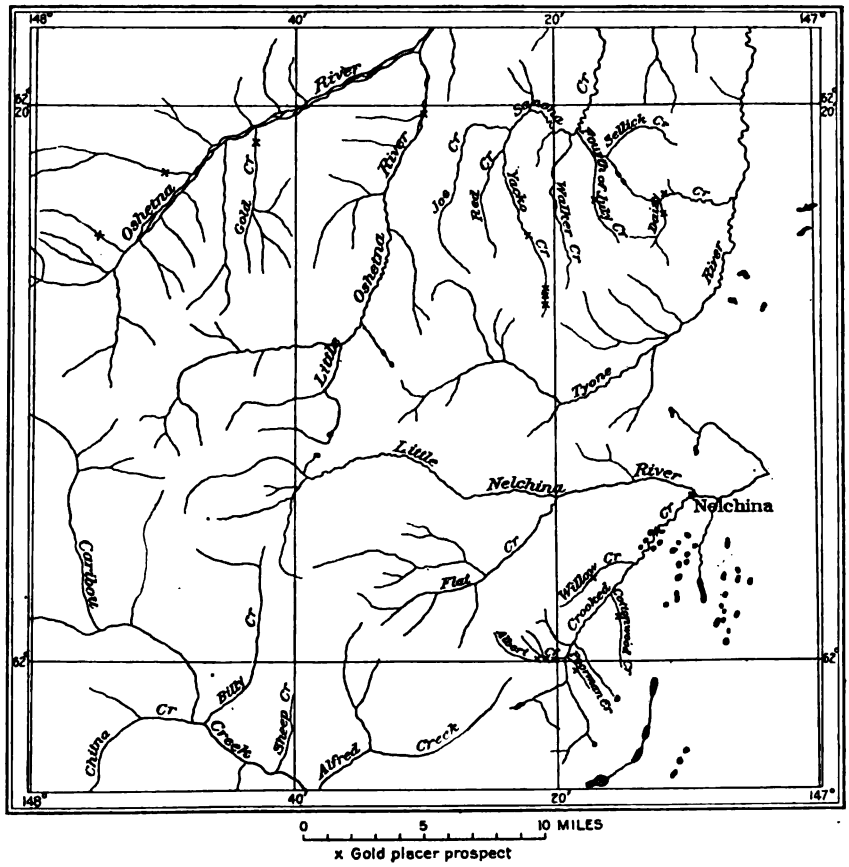


FIGURE 3.—Sketch map showing location of placers in the Nelchina region.

The stream gravels are largely of glaciofluvial origin, and except for a narrow strip along each stream course have not been reworked. These conditions account in part for the failure to find workable deposits in a region where auriferous gravels are so widely distributed. The extensive deposits of glacial gravel appear to contain a wealth of disseminated gold, but owing to lack of reconcentration they give little promise of yielding valuable returns.

Although most of the alluvial gold is believed to have been derived from the glacial gravels, it is possible that locally streams were enriched from other sources. Paige and Knopf[1] suggested that the gold content of the streams was derived by reconcentration from the Upper Jurassic conglomerates. These rocks, however, can not now be regarded as even a contributing source, for the beds of eroding streams show no gold enrichment where they cross the conglomerate formation. Small veins in the bedrock are regarded by Martin[2] as a possible source of the gold. Veins are not conspicuous in this region and are not regarded as a general source of gold, although they may have contributed a part of it.

The hope for developing workable gold placers in this region lies in finding either a stream in which a reconcentration of the glacial deposits has taken place or a channel of preglacial gravel.

The geologic formations of this region in which gold lodes are most likely to be found are the greenstone and schist formation, the Triassic schist and slate, and the Lower Jurassic lavas. These formations are all more or less mineralized, although they are not known to contain gold lodes in this region.

GOLD PLACERS.

CROOKED CREEK.

Crooked Creek is tributary to Little Nelchina River. It flows in a meandering course through a broad, flat, gravel-filled valley bordered by low glaciated hills. The entire course of the stream has been covered by locations, but little actual prospecting has been done except on its tributaries.

One claim, however, is being vigorously prospected. On "No. 19 below" a shaft was sunk during the summer of 1914 to a depth of 180 feet, and winter work was planned to drive the hole to bedrock if possible. The following log furnished by the operators shows the character of a part of the section:

Log of shaft on claim "No. 19 below," Crooked Creek.

	Feet.
Glacial capping, frozen muck, and gravel	85
Gravel	2
Silt	10
Blue-gray gravel composed of quartz and basaltic lava, with no clay or silt. Contains 5 colors in gold to the pan	9
Vegetable muck with willow twigs	12
Clay seam.	

[1] Paige, Sidney, and Knopf, Adolph, Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska: U. S. Geol. Survey Bull. 327, p. 67, 1907.

[2] Martin, G. C., and Mertie, J. B., jr., Mineral resources of the upper Matanuska and Nelchina valleys: U. S. Geol. Survey Bull. 592, pp. 280–281, 1914.

	Feet.
Gravel	2
Gas-bearing vegetable muck[1]	15
Blue-gray gravel	8
Yellow gravel	6
Clean gravel containing no silt or clay	10

ALBERT CREEK.

Albert Creek is the only stream in the Nelchina region that has produced any gold. The discovery was made in the fall of 1912, and 10 claims were staked the next spring by Odin Olson, Fred Getchell, Joseph Palmer, and Duncan McCormick. Much of that season was spent on dead work, but a cut 34 by 39 feet was opened and yielded about 60 ounces of gold. The average yield of the gravel was over $10 a cubic yard. Development work was continued in 1914 on a lease. In June over half a mile of ditch was completed and a strip of ground was being ground-sluiced preparatory to sluicing. Work was suspended early in the fall. It is reported that 150 ounces of alluvial gold was recovered. Prospecting was done by a number of other men on the creek, with indifferent success.

Albert Creek is a small stream about 3 miles long that enters Crooked Creek 9 miles from its mouth. Three main tributaries are locally known as Money Gulch, Porphyry Gulch, and Noon Gulch. The bedrock on Albert Creek consists of tuffaceous sandstone and shale, associated with volcanic rocks. It is overlain by about 5 feet of poorly stratified coarse gravel containing many flat and angular bowlders of graywacke. The alluvial gold is disseminated through this gravel, with little or no concentration on the bedrock. The coarse gravel is overlain by 2½ feet of finer gravel and clay and lenses of ice and 2 feet of silt and clay. The pay streak does not appear to be continuous, but prospecting has not yet been adequate to prove or disprove its extent or value. Timber for cabins and mining purposes was brought from Startup, a camp at the head of Squaw Creek, 6 miles south.

OTHER TRIBUTARIES OF CROOKED CREEK.

Prospecting was being done in 1914 on other tributaries of Crooked Creek. Six men were at work on Poorman Creek and early in the summer had ground-sluiced 350 feet of ground and had boxes ready to set up. The bedrock on the lower part of the creek consists of conglomerate, shale, and sandstone and on the upper part of vesicular red andesitic lava with beds of white tuff. At the workings the bedrock is about 6 feet deep. The gold is rather flaky, but

[1] The gas that escaped from this stratum was sufficient to ignite and to cause a slight explosion.

contains small nuggets. It is reported that a small production was made. A little prospecting was done on Cottonwood Creek, but bedrock was not reached. Prospecting was also done on Bonanza Creek, South Creek, Willow Creek, and other small tributaries.

LITTLE NELCHINA RIVER.

A number of claims have been staked on Little Nelchina River, but little work has been done. The nature and depth of the gravels of the Little Nelchina are not known, as bedrock is not exposed. The gravels have not been exposed by mining and only slightly by erosion, as the stream is not actively cutting its channel. Low benches along its border are composed of coarse glacial material. To judge by the depth of the gravel on Crooked Creek the Little Nelchina bedrock is also deep.

YACKO CREEK.

Yacko and Joe creeks unite to form Sanona Creek, one of the tributaries of Tyone Creek. Several men were prospecting on Yacko Creek in 1914. Bedrock was not reached, but enough alluvial gold was found in the overlying gravel to encourage further work. The gold is coarse and flat. The contact between the volcanic rocks and the Mesozoic sediments crosses this stream. Above this contact the stream flows over a wide, flat valley bounded by rounded hills, but where it enters the volcanic rock the valley narrows into a canyon and the hills are much more rugged.

FOURTH OF JULY CREEK.

Two prospectors worked during the summer on Fourth of July Creek, a small tributary of Sanona Creek. They reported fine colors of alluvial gold but failed to find gold in encouraging amounts.

DAISY CREEK.

Daisy Creek is being worked at several places, and fair prospects have been found. The bedrock on the lower part of the creek is lava; on the upper part, sandstone and conglomerate. The upper valley is wide and flat, but where the stream enters the volcanic rock the valley narrows to a canyon, below which it widens out considerably. The gravel is shallow, ranging from 5 to 12 feet in depth, but the prospectors had considerable trouble with ground water. In the fall of 1914 a prospecting drill was taken in to prospect the creek during the winter.

OSHETNA RIVER.

Several prospects were located on tributaries of Oshetna River in 1914. Alluvial gold occurs in the gravels of Little Oshetna River, but there is little or no concentration in pay streaks on bedrock. Prospectors on Gold Creek found coarse gold but had difficulty in getting to bedrock on account of the ground water. They planned to continue winter development. Enough alluvial gold to encourage further prospecting was also found on Granite and Roaring creeks, small tributaries 11 and 13 miles, respectively, above the mouth of Little Oshetna River.

MINING ON PRINCE WILLIAM SOUND.

By BERTRAND L. JOHNSON.

GENERAL FEATURES.

The lode-mining districts of Prince William Sound may in a general way be grouped into two concentric belts, concave southward, the outer one including the gold quartz districts and the inner one including the copper camps. The copper mines produce also large amounts of gold or silver, or both; and the gold mines produce also some silver. The ores of the gold quartz districts are free milling. The copper ores are smelted at Tacoma, Wash., and their content of valuable metals is recovered during this process. The metallurgic treatment of the gold quartz ores is performed locally in small stamp or roller mills, with amalgamation; the concentrates are shipped to the Tacoma smelter. A much larger tonnage of copper ore than of gold quartz ore is mined and treated, and the total value of the metals produced from the copper ores is about five times that obtained from the gold quartz ores. The only placer deposits in the region are gold placers, and these are found only in the gold quartz districts and have been little developed.

The productive mines of the Prince William Sound region in 1914 included two copper mines and eight gold mines. Most of the gold mines were in the Port Valdez district. Besides these properties, a prospect on Knight Island made a small shipment of copper ore to Tacoma, and the Golden Eagle stamp mill, at Golden, is said to have been in operation a few days in the fall.

COPPER MINING.

GENERAL CONDITIONS.

Copper mining and prospecting in the Prince William Sound region was curtailed somewhat in 1914 compared with the previous year, chiefly owing to the low price of copper. The Beatson Copper Co. and the Ellamar Mining Co. made regular shipments as usual, but the other properties which in previous years had shipped copper ore to the smelters in the United States were either idle or had only a little development work done on them, except that a small

shipment of ore is reported from one property on Knight Island. Development work was done on a few of the nonproducing prospects, and assessment work on many others. All the copper ore shipped consisted of crude sulphide ore in which the copper-bearing mineral was chalcopyrite. So far as known the ores all went to the Tacoma smelter. Extensive preparations were made by the Granby Consolidated Mining, Smelting & Power Co. (Ltd.) to put the Midas mine, on Solomon Gulch in the Port Valdez district, on a producing basis, but the European war caused a cessation of all development work at that property late in the summer.

The producing copper properties on Prince William Sound appear to have been only slightly affected by the confusion in the financial and copper markets resulting from the war. An increased quantity of copper ore was mined in 1914, but the average grade of the ore mined was much lower than in the preceding year. The value of the metals recovered from these copper ores in 1914 was also less than in 1913. This decrease was due largely to the lower grade of the ore mined, although the lower price received for the copper content of the ores contributed slightly to the decline in the total value of the production. It appears probable that the future position of Prince William Sound as a copper producer depends on the successful treatment of the lower-grade copper ores by concentration or by a marked lowering of mining and metallurgic costs through some radical change from present methods, possibly the erection of a local smelter. The only change in either mining or metallurgic treatment of the copper ores of Prince William Sound that is known to have taken place in 1914 was the introduction at the Beatson-Bonanza mine, on Latouche Island, of a mechanical concentration process for the recovery of the valuable metals in the ore. Previous to this innovation hand-sorting only had been used at the producing properties of the region.

LATOUCHE AND KNIGHT ISLANDS.

The Beatson Copper Co., operating the Beatson-Bonanza mine, on Latouche Island (Pl. VII, p. 138), continued to ship crude chalcopyrite ore to the Tacoma smelter. During the year a large plant for the concentration of the lower-grade ores, chiefly by a flotation process, was nearly completed at this mine. Development work at the mine was continued as usual by open cuts, tunnels, and drifts.

A few tons of copper ore is said to have been shipped from Knight Island to the Tacoma smelter by the Seattle Alaska Copper Co., which also reports driving 140 feet of tunnel in an ore zone 9 to 10 feet wide on its claims. The Blackbird group of the Latouche Copper Mining Co. was not operated in 1914. This property is said to be developed by a crosscut tunnel 736 feet long, a 280-foot drift on

the vein, a 242-foot raise to the surface, and several short drifts. The Knight Island Copper Mining Co. reports 25 feet of drifting, some open-cut work, and prospecting in 1914. Assessment work was done on the Una group, which is now developed by 65 feet of tunnel.

ELLAMAR DISTRICT.

The Ellamar Mining Co. operated its mine and plant throughout the year, making regular shipments of crude sulphide ore to the Tacoma smelter. The entire sulphide body is now being mined as ore, and the mine is a large producer of both copper and gold, with smaller amounts of silver. The underground development work in 1914 lay between the 400-foot level and the surface, and some raises, drifts, and crosscuts were run in the slate country rock. The filling system is used, the change to this system having been made in 1913. A maximum force of 72 men was employed on the property during the year. This was reduced to 60 men in October. A station for loading ore on large steamers was erected on the bar at the entrance to Virgin Bay, and an aerial tramway with several towers was installed, connecting this station with the mine buildings. An illustrated description of this new tram line has recently been published.[1] New 1,200-ton ore bunkers were in process of erection in the fall, close to the old ore bunkers at the landward end of the wharf.

No ore shipments were made from any of the Landlocked Bay properties. Two men were at work on the Montezuma claim of the Threeman Mining Co., and ore is reported to have been found on both the Montezuma and the old Alaska Commercial Co. claims. The Landlock Bay Copper Mining Co. had two or three men engaged in development work, and a little development work was also done on the property of the Hemple Copper Mining Co. in the spring. No mining was done in 1914 at the Standard property. At Galena Bay the claims of the Galena Bay Mining Co., at the head of Vesuvius Valley, were surveyed for patent.

PORT VALDEZ DISTRICT.

The developments and ore deposit at the Midas mine, the property of the Granby Consolidated Mining, Smelting & Power Co. (Ltd.), and the only copper property in the Port Valdez district, are described in a preliminary report on that district (pp. 140–188).

PORT FIDALGO.

Development work is reported on two of the Port Fidalgo copper properties (Pl. VII). On the Dickey Copper Co.'s ground (formerly

[1] Aerial ship-loading system at Ellamar, Alaska: Eng. and Min. Jour., vol. 99, pp. 230, 249, 1915.

the Mason and Gleason claims) three men were engaged in development work, and ore is said to have been found during the year on a new lower level. The Fidalgo Mining Co. made no shipments in 1914. Development work was actively prosecuted in the early part of the year, but the working force was decreased to two men early in the spring, and no work was done after June 1. The developments since the writer visited the property in 1913 consist of stoping operations between the two levels and between the upper level and the surface, the extension of the main tunnel to a length of 650 feet, and the opening of a 20-foot raise between the main level and the overlying ore shoot. A new ore shoot was also encountered about 600 feet from the portal of the main tunnel.

UNAKWIK INLET, WELLS BAY, AND GLACIER ISLAND.

Assessment work was done on several properties on Unakwik Inlet, Wells Bay, and Glacier Island. New copper prospects are reported to have been discovered in the vicinity of Wells and Long bays.

GOLD MINING.

GENERAL CONDITIONS.

Both gold quartz lodes and gold placers occur within the Prince William Sound region, but the placer deposits are few, small, and spotted and have been worked only intermittently and on a small scale. The annual placer production is probably only a few hundred dollars. The interest in gold quartz mining in 1914 centered in the Port Valdez, Tiekel, and Port Wells districts, as in the preceding year. The mining developments in the Port Valdez district are discussed in the preliminary report on that district (pp. 140–188). In the Tiekel district considerable development work is reported on several prospects. No data are available as to developments on gold quartz prospects along the Prince William Sound shore of Kenai Peninsula and in the McKinley Lake district. A short trip was made in the fall of 1914 to the Port Wells district, and the data then obtained are given here.

PORT WELLS DISTRICT.

GENERAL FEATURES.

The distribution, geologic relations, characteristics, and economic features of the gold deposits of the Port Wells district, together with the developments up to and including 1913, were briefly described in a recent report.[1] Since that report was written the Port

[1] Johnson, B. L., Mining on Prince William Sound: U. S. Geol. Survey Bull. 592, pp. 237–243, 1914.

Wells district has increased considerably in importance as a gold quartz camp. Two mills were erected in 1914, one of which was in operation the greater part of the year. The Granite mine, formerly known as the Tatum property, is now the most productive property in the Port Wells district and has become, since the closing of the Cliff mine at Valdez, the largest producer among the gold quartz m[illegible] of the Prince William Sound region. Considerable underground development work was done in 1914 on a few properties, and assessment work was done on many claims. A few new discoveries have been made, principally on the west side of Port Wells between Portage Bay and the Granite mine. Business at Golden is said to have been a little slacker than in 1913 but to have lasted longer. In the fall of 1914 there was reported to be a permanent population of about 150 men in the district. Transportation facilities have improved, and several ocean steamers touched in the Port Wells district during the summer. Regular mail and passenger service was also maintained between Valdez and several points on Port Wells. The only post office in the district is at Golden.

The following notes regarding recent developments on the several prospects are grouped by separate fiords and bays, so far as possible. With the exception of the Granite mine none of the properties in the district were visited in 1914, but the data presented were procured from what are believed to be reliable sources. There are many other prospects in this district on which assessment or development work may have been done, but no data are available regarding them.

AVERY RIVER.

A milling plant consisting of a rock crusher and a single-stamp Moyle mill having a capacity of 3 tons in 24 hours was erected on the Consolidated claim, on Avery River, in 1914. The mill was run intermittently during the season and several tons of ore was milled.

The property is developed by two shafts, 61 and 21 feet deep. Ten feet of work is reported to have been done on the Avery River property of the Sweepstake Mining Co. in 1914.

GOLDEN AND VICINITY.

A few new discoveries have been reported in the vicinity of Golden, including a new lead in a new tunnel on the Nugget claim and a lead discovered by H. C. and H. R. Johnson. On the Golden Eagle claim a 5-stamp mill was erected close to the lagoon below the tunnels and is reported to have been in operation a few days in the fall. The mill is connected with the underground workings by a short aerial tram. Only a little underground work is reported. Fifteen men

are said to have been at work on this property in October. The arrastre erected on the Tolson & Stanton property in 1913 was not in operation during the year. Several feet of tunnel was driven on the Golden Wonder No. 9, and 90 feet of tunnel was driven on the Gold Queen prospect of Hanson, Gustafson & Berklund, and camps were established.

SHORE OF PORT WELLS BETWEEN HOBO BAY AND HARRISON LAGOON.

The present importance of the Granite mine justifies a rather extended description. It is situated on the west side of Port Wells, on an eastward-facing timbered slope bordering a small bight in the coast between Hobo Bay and Harrison Lagoon. The original discovery, at an elevation between 500 and 600 feet, is on the end line between the Port Wells No. 1 and the Port Wells No. 2 claims. A good road extends from the shore to the mine camp and workings.

The vein was discovered July 19, 1912, by M. L. Tatum and Jonathan Erving, and a shaft was sunk on the vein. A shipment of 5 tons of ore taken from this shaft is said to have been made in the following December. In 1913 the property was bonded to B. F. Millard, who later organized and incorporated the Granite Gold Mining Co., the present owner of the property. Development work was actively carried on in 1913 and 1914, and the property was raised to its present position as the largest producer among the gold quartz mines of the Prince William Sound region. The underground developments on August 22, 1913, included a 30-foot inclined shaft, a 170-foot crosscut tunnel with two drifts on the vein, 75 and 60 feet long, 150 feet from the mouth of the tunnel, and some surface stripping. On October 5, 1914, the underground workings consisted of the original 30-foot inclined shaft; a main level reached by a 170-foot crosscut tunnel, which cuts the vein 150 feet from the portal of the tunnel, with about 450 feet of additional crosscuts and drifts, about 250 feet of which are along the vein; an 85-foot raise extending upward from the main level toward the inclined shaft on the surface; a 154-foot raise from the main level to the surface; a 130-foot inclined shaft, 7½ by 11 feet, extending down from the main level; a 50-foot level, 44 feet vertically below the main level, with 330 feet of drifts along the vein; a station cut 70 feet vertically below this level, with a short crosscut to the lead, and stopes between the 50-foot level and the main level and between the main level and the surface.

The surface improvements on the property include a well-graded wagon road from the shore to the mine; mill buildings at an elevation of about 200 feet housing a 7-foot Chilean mill, a breaker, rolls, a No. 4 concentrator, and another concentrator, all driven by gasoline

engines; an aerial tram from the mill to the ore bunkers, near the mine workings; and several buildings. The entire plant and mine are electrically lighted. Machinery on the property includes an air compressor, hoist, triplex sinking pump, gasoline engines, and drills.

Milling operations are said to have started March 14, 1914, and the mill had been running continuously, except for clean-ups and a short stop in August for repairs, at the time the property was visited. The tailings from the mill are ponded. From 30 to 45 men were employed during the season. Two shifts were worked underground, and three shifts in the mill and power house.

The country rock of the ore body consists of interbedded slates, graywackes, and argillites cut by large masses of medium-grained biotite granite, hydrothermally altered near the veins to a light-gray to greenish-gray rock. The granite contacts are said to be irregular.

The developments suggest the presence of more than one lead on the property, but are not sufficiently advanced to prove it. The vein showing in the shaft occupies a fissure striking S. 75° W. and dipping 60° N. In the underground workings considerable variation in the strike and dip of the vein is noticeable in the several drifts. In 1913 observations seemed to show that the vein had a general strike between N. 50° W. and N. 70° W. and a dip of 43°–55° N., and it is reported to be offset in many places by small faults. The fissure ranges from 3 inches to 14 feet in width and averages perhaps from 3 to 3½ feet. The fissure filling varies with the character of the country rock. In the sedimentary rocks it consists of shattered slate, graywacke, and argillite, with quartz veins or a quartz network cementing the shattered rocks and inclosing angular fragments in a network of porous white crystalline quartz. In the granite the vein is stronger and better defined, although its widest part includes numerous shattered masses of altered granite cemented by gold-bearing quartz veinlets.

The original shaft was all in slate and graywacke. The lead now under development cuts both sediments and granite, but most of the development work has been in the granite. In the main level the hanging wall of the vein is granite. Between the main level and the 50-foot level the lead lies along the contact of the granite and the sedimentary rocks, and the shaft was sunk along the vein, which here had a dip of 45°. On this level everything in beyond the shaft is said to have granite on both walls, and below this level both shaft and vein are reported in granite but the dip of the vein has changed to 35° N. Between the 50-foot level and the next lower level several parallel quartz veins with a maximum width of 14 inches cut across the shaft toward the main vein. In the station and crosscut on the lower level some of these leads join the main vein, increasing its width to 4 feet.

There are good walls to the veins in the granite on the 50-foot level, but little gouge, although the quartz breaks free from the walls. The same is true in the crosscut on the lower level. In the lead in the original surface shaft gouge shows on both walls of the fissure.

The gangue minerals of the Granite mine ore include quartz, calcite, and a brownish-weathering carbonate. The metallic ore minerals are gold, pyrite, sphalerite, stibnite, galena, arsenopyrite, and chalcopyrite. In one specimen both light-colored and medium-colored gold were seen, so it is probable that the grade of the gold varies considerably in different parts of the vein. Stibnite is in places very closely associated with the richer gold ore. The sulphides are not particularly abundant in the ore, forming, according to report, but 2 per cent by weight of it.

A new lead is said to have been discovered in 1914 about 700 feet from the Granite mine, on the contact of the same granite intrusion.

MISCELLANEOUS LOCALITIES IN THE PORT WELLS DISTRICT.

Considerable development work is reported on the prospect of Everson, Gauthier & Cooper, on Hobo Bay. The crosscut tunnel is said to have been lengthened to 172 feet, the lead crosscut, and some drifting done on the lead. Surface strippings are said to expose the lead for about 1,500 feet. The prospect is reported by the owners to be developed by a 25-foot shaft and 300 feet of drifts.

On the Mineral King claim of Hermann & Eaton about 90 feet of drifting is reported to have been done on the lead on the 100-foot level between November, 1913, and March 1, 1914, and the developments are now said to include a 110-foot inclined shaft and 150 feet of drifts on the 100-foot level. The tunnel on the Yakima ledge is said to have been extended to 50 feet.

The developments on the Tomboy group, on Pigot Bay, now include a 40-foot adit and a 20-foot winze on the vein on the Tomboy No. 2, and a 35-foot tunnel on Tomboy No. 3, on a vein discovered in 1914. Twelve men were employed on the property until December 22, 1914. Several tons of ore from the new vein was milled in Valdez.

Several veins are said to have been discovered on different parts of Pigot Bay during the summer.

A gold quartz vein is reported to have been discovered on Passage Canal, late in the fall, by Guy Banta and Harvey Sullivan.

The Hummer Bay prospect of Everson, Harris & Parker is said to be developed by two tunnels, 30 and 138 feet long, and by a 15-foot shaft.

Assessment work only is reported on the Barry Arm prospects.

On the Black & Hogan claims, on Harriman Fiord, the Tar Flat group, 250 feet of tunnels and two shallow shafts are said to have been driven on the vein at an elevation of about 100 feet above sea level. Ten feet of underground work is reported to have been done on the Harriman Fiord property of the Sweepstake Mining Co.

The Eldorado claims of White & Pedersen on Eaglek Bay were under development by the Alaska-Washington Gold Mining Co., and at the close of 1914 the total length of drifts and crosscuts was reported to be 375 feet.

Two new discoveries of gold quartz were made on the east side of Eaglek Bay, thus extending the known gold-bearing area of the Port Wells district a little farther eastward.

The Thomas-Culross Mining Co. did considerable development work on the Bugaboo and Chelan claims on Thomas Bay, Culross Island, during the first 10 months of 1914. The developments now include a 140-foot crosscut tunnel to the fissure, a 175-foot drift on the vein from this crosscut tunnel, and a 28-foot vertical shaft sunk on the vein. All this work except the crosscut tunnel was done in 1914. A shipment of several tons of ore from these workings was made to the smelter.

THE GOLD AND COPPER DEPOSITS OF THE PORT VALDEZ DISTRICT.

By BERTRAND L. JOHNSON.

INTRODUCTION.

The object of this preliminary report is to describe briefly the distribution, geologic relations, and characteristics of the mineral deposits of the Port Valdez district (Pl. VIII, p. 186). A brief presentation of the geographic factors bearing on the economic development of the mineral deposits of the district precedes a discussion of the geology. The general description of the mineral deposits is followed by detailed descriptions of many of the ore bodies.

Detailed geologic mapping was begun in the Port Valdez district in 1914 by the writer, assisted by G. L. Harrington. Mr. Harrington also assisted in the preparation of this report, which is only preliminary. A more complete account of the geology and mineral resources will be prepared when the final mapping and studies have been completed.

GEOGRAPHY.

The Port Valdez district lies in the northeastern part of the Prince William Sound region and comprises the area immediately tributary to Port Valdez. (See Pl. VIII.)

The district is one of strong relief. The mountains inclosing the fiord rise abruptly from sea level and in parts of the district attain elevations of 4,000 feet within a mile of the coast. The main range, which has a maximum elevation of 6,970 feet, lies north of Port Valdez. A well-defined but less rugged range, with peaks from 2,000 to 5,425 feet above sea level, forms the mountainous spur south of Port Valdez. The continuity of the main range is broken only by the high pass (4,800 feet) occupied by the Valdez Glacier. A few lower passes, 2,000 to 2,500 feet above sea level, cross the spur range between Port Valdez and Columbia Glacier.

The entire Port Valdez district has been intensely glaciated in recent times, and, as in other districts of alpine glaciation, two distinct types of topography have resulted—one shaped by frost action above

the surface of the glaciers, with sharp peaks, cirques, and narrow, steep-walled, comblike ridges, and the other with the rounded features of an area overridden and smoothed beneath glacial ice. The characteristic sharp, angular forms developed by high-level erosion appear at elevations above 4,000 feet. Practically all of the district below this elevation is characterized by the rounded summits, slopes, and U-shaped valleys produced by glacial abrasion.

In pleasing contrast to the rugged relief of most of the district are the broad, gravel-covered, timbered lowlands that border the head of Port Valdez. These plains, which slope gently seaward, all lie below an elevation of 250 feet above sea level. The Valdez and Mineral Creek plains have a slope of only 50 feet to the mile, and the gradient of the Lowe River flats is even less.

The glaciers that cover much of the area north of Port Valdez are, with the exception of Anderson Glacier, of the alpine type. Columbia Glacier, the largest in the Prince William Sound region, borders the northwestern part of the district. The long ice tongue of Valdez Glacier debouches on the gravel plain at the head of Port Valdez. Shoup Glacier discharges into Shoup Bay. Mineral Creek heads in a valley glacier, and numerous hanging glaciers occur in this and other valleys. Anderson Glacier caps the mountainous area between Sawmill and Shoup bays and occupies a pass between Shoup Bay and Columbia Glacier. South of Port Valdez only a few small glaciers remain.

The shore line is remarkably even. The shores are mostly steep, in places precipitous, and rocky, with a few small rock peninsulas and islands. The head of Port Valdez is fringed by a wide mud flat, and smaller flats adjoin the mouths of many of the streams. The otherwise even shore is dented by three small bays—Jack, Sawmill, and Shoup bays.

Most of the drainage of the district enters Port Valdez. The streams drain small areas, and are mostly short, and as they derive a considerable part of their water supply from melting snow and ice, the stream flow is subject to wide variations during the year.[1] Two power plants are in operation on Solomon Gulch, and some smaller plants are utilized during the summer. There are also some undeveloped water powers in the district.

COMMERCIAL CONDITIONS.

Valdez, the supply point of the district, with a population of about 1,500, lies at the head of Port Valdez, which is open to navigation throughout the year. It is the coastal terminus of the Valdez-

[1] Ellsworth, C. E., and Davenport, R. W., Preliminary report on a water-power reconnaissance in south-central Alaska: U. S. Geol. Survey Bull. 592, pp. 178–179, 1914.

Fairbanks military road. It is connected by cable with Seward, Cordova, Juneau, and other points on the Alaska coast and with Seattle, and by telegraph with Fairbanks. Valdez can be reached in six days by steamer from Seattle. Two companies operate steamers to Valdez, giving a service in summer of eight times a month and in winter of four to six times a month. Freight charges from Seattle to Valdez (1915) vary from $3 to $40 a ton according to classification. Transportation for passengers (1915) costs $45 for first class and $25 for second class.

Valdez is provided with wharves, banks, hotels, stores, public schools, telephones, and electric lights. A good stock of supplies is kept on hand, and prices are not high except for fuel. Gasoline in 1914 cost 45 cents a gallon in 10-gallon cases, and British Columbia coal retailed at $12.50 a ton delivered. The town has in the past been subjected to occasional disastrous floods of the streams from Valdez Glacier, but it is now protected by a dike built in 1913–14.

On the south side of Port Valdez wharves have been built at Solomon Gulch, forming the coastal terminal for the aerial tram of the Midas mine, and at Fort Liscum, an army post. Wharves have also been built at the mouth of Mineral Creek and at the Cliff mine. A wagon road has been built from the Mineral Creek wharf to a point 5 miles up Mineral Creek, and one up Solomon Gulch to the Midas mine. The other properties have been connected with tidewater by trails, some of which traverse the glaciers.

Transportation along the coast is effected largely by the use of gasoline launches, some of which give a regular service to the Port Wells district. Launches can be chartered at a cost of $10 to $30 a day. Wages in the district are about $3 to $4 a day and board. At the height of the mining season in summer it is not always possible to obtain the services of experienced lode miners, though there are a number of them in the district.

The climate of the Port Valdez district is somewhat colder and drier than that of neighboring districts on Prince William Sound, which are more directly exposed to the influence of the Pacific Ocean. Records at Valdez show a total annual precipitation of about 56 inches; at Fort Liscum, on the south side of the bay, it is 74 inches. The average annual snowfall is about 30 feet. The average temperature for the three summer months is about 52° F. and for the three winter months about 21° F. At higher elevations the climate is more severe. The steep slopes and heavy snowfall lead to numerous snowslides, and this is one of the elements the miner has to contend with in winter work in the district.

Timber is scarce in the Valdez district, but there is some in the Lowe River valley and at Sawmill Bay. Trees 5 feet in diameter

may be found, but the average size is very much smaller. Spruce and hemlock predominate, although on the Valdez and Lowe River flats cottonwoods are more abundant. The upper limit of timber is irregular, extending from sea level to 1,500 feet. Timber is also obtainable from Port Fidalgo, 20 miles to the south. The local timber is suitable for mine workings and rough lumber, but the better grades of lumber are brought from Seattle. The Port Valdez district is included in the Chugach National Forest.

In the lowlands, which are not extensive, there is some good grass, but most of the horse feed is brought from Seattle. Small local gardens supply the hardier vegetables and these, with fish and small game, are the only local sources of food supply.

To summarize the commercial conditions: Equipment and supplies can be landed at tidewater on Port Valdez at no great cost. Transportation to inland properties, however, is usually rather expensive. Fuel is costly, but other supplies are comparatively cheap, and wages are not high. Timber, though not locally plentiful, can be brought from points near by. Underground operations can be carried on throughout the year, and mills can also be operated the entire year where a permanent water supply is available. Waterpowers available throughout the year are not abundant.[1] The opening of the Bering River and Matanuska coal fields should give comparatively cheap fuel. The strong relief is favorable to the undercutting of lodes, where good evidence of their persistence at depth is shown, doing away with the necessity of pumping. Lodes located at tidewater, like that of the Cliff mine, necessitate the sinking of shafts and pumping of water.

GEOLOGY.

OUTLINE.

The Port Valdez district lies in the southern part of the Chugach Mountains, which so far as known consist of metamorphosed sedimentary rocks, chiefly slates, argillites, graywackes, and conglomerates with minor amounts of greenstones and limestones, altered in many places to schistose rocks by dynamic and contact metamorphism. The age of these rocks is unknown, but is probably either late Paleozoic or early Mesozoic. The intrusives which cut these sedimentary rocks are believed to be of Mesozoic and later age.

Earlier workers in this part of the Prince William Sound region and the Chugach Mountains have subdivided the rocks of this area

[1] Ellsworth, C. E., and Davenport, R. W., op. cit., pp. 170–180.

into two great divisions—the Valdez and Orca groups.[1] The Valdez group was presumed to be the older and more metamorphosed and was described as consisting principally of slates and graywackes. These Valdez rocks were believed to be unconformably overlain by another great series of less altered sediments of similar lithologic types, named the Orca group. The Orca rocks consist of interbedded slates and graywackes with extensive greenstone flows and agglomerates as well as thick conglomerate beds. Granitic rocks were reported to intrude both Orca and Valdez groups.

The major part of the Port Valdez district as mapped by Grant and Higgins[2] lies within the Valdez group of these writers. The

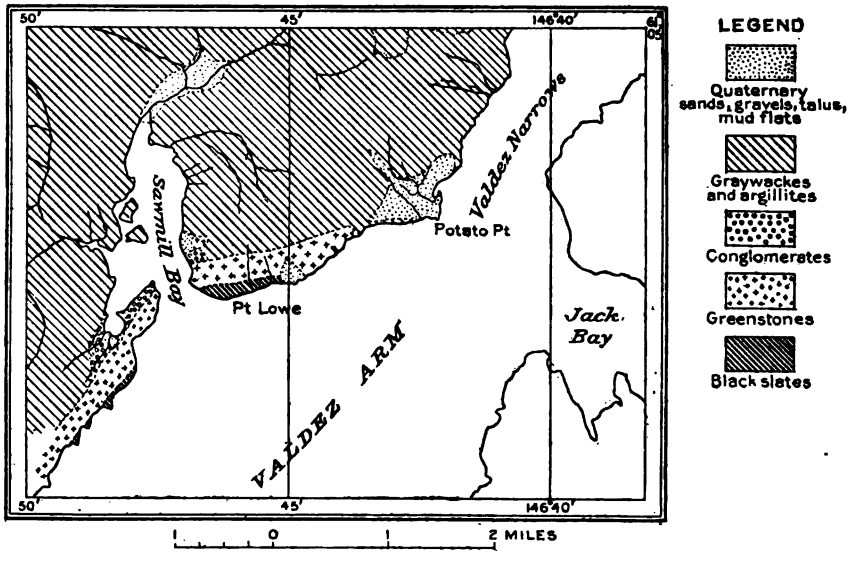


FIGURE 4.—Geologic sketch map of the vicinity of Sawmill Bay.

boundary of the Valdez and Orca groups is placed by them at the entrance to Valdez Narrows, and a large part of the area between this locality and Point Freemantle is mapped as the Orca.

The conclusions reached as a result of the 1914 field work are tentative, but the evidence collected suggests a stratigraphic succession markedly different from that outlined above. The geologic section as now understood appears comparatively simple and consists of

[1] Schrader, F. C., A reconnaissance of a part of Prince William Sound and the Copper River district, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 404–417, 1900. Schrader, F. C., and Spencer, A. C., The geology and mineral resources of a portion of the Copper River district, Alaska: U. S. Geol. Survey Special Pub., pp. 32–40, 53, 1901. Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, pp. 20–33, 51–52, 1910.

[2] Idem, pl. 2.

slate, greenstone, conglomerate, graywacke, and argillite, deposited in the order named. No conclusive evidence was seen for the existence of an unconformity between any two of these formations. The Sawmill Bay area, although closely folded and faulted, was found to offer the best clue to the stratigraphic succession in this district, and the small geologic sketch map (fig. 4) shows the distribution of the formations in this vicinity. North of this area, however, the rocks have undergone greater dynamic metamorphism and present an intricately folded complex which, so far as the present field work shows, includes slightly altered as well as schistose types of all members of the stratigraphic succession named above. This complex borders the shores of Port Valdez and covers most of the district. Less deformed beds occur, however, in the extreme northeastern part of the district, in the valley occupied by Valdez Glacier. The use of the term "Valdez group" as at present commonly understood does not seem justified by recent work. This question will be discussed in full in the final report on this district.

SEDIMENTARY ROCKS.

The pre-Quaternary rocks are almost entirely of regionally metamorphosed types. The variety of sedimentary rocks is not great. Four lithologic subdivisions may be made—(1) black slates, (2) greenstones, (3) conglomerates, (4) graywackes and argillites. The stratigraphic sequence is apparently that in which they are mentioned here. Other metamorphic varieties are found which have resulted from the regional metamorphism of these units. Rocks altered by the contact metamorphism produced by granitic intrusions also occur within the district but cover only very small areas.

BLACK SLATES.

The black slates occupy an inconsiderable part of the area. The largest and most typical exposure is a strip lying east of the greenstone band at the mouth of Sawmill Bay. The slates are predominantly dark-gray to black, very fine grained rocks, with a well-developed slaty cleavage. This division, in contrast with the other sedimentary rock groups of the district, is characterized by a relatively small percentage of graywacke. Within the metamorphic complex that covers most of the Port Valdez district are small infolded areas of these slates, locally in intimate association with sheared greenstones or green schists. Examples of these occurrences are to be seen on the east side of Valdez Glacier at the Rose Johnson property, on Mineral Creek below Brevier Creek, on the south side of Port Valdez near Jackson Point, on the west side of the Valdez

Narrows near the lighthouse, near the head of Clear Creek, on Twin Falls Creek, and between Anderson and Columbia glaciers. A slaty or schistose structure has been developed by dynamometamorphic processes in many of the other rock groups of the district, but rocks having this structure must be carefully distinguished from the typical black slates, which have distinct lithologic characters and considerable thickness. The belt at the mouth of Sawmill Bay is about 800 feet wide, and much larger exposures occur in the Ellamar district.

GREENSTONES AND GREEN SCHISTS.

The greenstones and green schists are derivatives of a series of basic lava flows, which locally display pillow structure. The maximum thickness of these rocks exposed within the Port Valdez district may be seen at the entrance to Sawmill Bay, where a steeply dipping band of greenstones 1,000 feet wide extends southwestward along the coast. Much smaller areas of greenstone occur in the west side of the Valdez Narrows, at the head of Solomon Gulch, between Anderson and Columbia glaciers, on Mineral Creek, within the valleys occupied by Valdez and Shoup glaciers, and on some of the northerly tributaries of Sawmill Bay. The least-altered greenstones are dark-greenish, heavy, fine to medium grained rocks, which on weathered surfaces have a characteristic brownish appearance when seen from a distance. Those at Solomon Gulch and Sawmill Bay are the least altered, and in the exposures at the mouth of Sawmill Bay the ellipsoidal structure is still evident. In other exposures, as on Shoup Bay, the west side of the Valdez Narrows, Mineral Creek, and in the Valdez Glacier drainage area, the original structure and texture have been almost completely masked by the later schistosity, so that the rocks now appear in many places as rather light green bands of chlorite schist or as thin chloritic bands complexly intersheared with black slates.

CONGLOMERATES.

The small area covered by the conglomerate in this district is not a clue to the stratigraphic significance of the formation, whose existence and situation are indicative of a pronounced change in conditions—a transition from the period of volcanic activity in which the basic lava flows occurred to the period of sedimentary deposition in which the thick graywacke and argillite series was laid down. The largest body of conglomerate is that lying above the greenstone on the peninsula at the entrance to Sawmill Bay, where it is 800 feet thick. This body is apparently continuous with the conglomerate area lying to the southwest, where scattered outcrops of conglomerate are visible over a width of about 1,500 feet, but it is questionable

whether the thickness exposed is the original thickness or whether there may not have been duplication of the beds through faulting. The contact of the conglomerate with the underlying greenstone is not exposed within the district, but because of the presence of numerous greenstone pebbles in the conglomerate, especially near the contact, the sequence may be safely assumed. This conglomerate has been tentatively correlated with a similar conglomerate at the entrance to Galena Bay, where the relations of the greenstone and conglomerate are more apparent. At that point the conglomerate "lies conformably upon the underlying greenstones, and although the conditions of sedimentation were greatly changed, coarser materials being carried into the sea and volcanic activity having ceased, it is believed that no time elapsed between the deposition of the greenstones and that of the conglomerate, but that deposition was continuous."[1] Other exposures of this conglomerate are on the east side of Sawmill Bay north of the greenstone, where its extent is limited by faulting, and on the Sawmill Bay and Cape Freemantle shore. Present indications also point to an exposure of conglomerate on the steep eastern slope of Point Lowe, but its stratigraphic relations are not definitely known.

In the type locality the texture of the conglomerate varies markedly. Near the greenstone contact there are many large bowlders, but farther away the pebbles are much smaller. They are mainly angular to subangular in shape; few are well rounded. The pebbles consist of greenstones, graywacke, argillite, and slate. The matrix is usually a dark-gray fine to medium grained graywacke material closely resembling in appearance the overlying graywackes.

A few conglomerate bowlders are found in the wash from Valdez Glacier. They are of essentially the same type of rock as those from the vicinity of Sawmill Bay. A small conglomerate bowlder found in the beach gravel on the east side of Valdez Narrows appears much less metamorphosed than any conglomerates known in place in this district. It also differed from the other conglomerates in having a very light colored sandy matrix with numerous embedded rounded pebbles of black argillite. It seems doubtful at present if this bowlder had its source within the Port Valdez district.

GRAYWACKES AND ARGILLITES.

The graywackes and argillites cover large areas within the Port Valdez district. They are especially well developed on Sawmill Bay and Valdez Narrows, on the south side of Port Valdez, and along the upper reaches of the Valdez Glacier. This graywacke and argil-

[1] Capps, S. R., and Johnson, B. L., The Ellamar district, Alaska: U. S. Geol. Survey Bull. 605, p. 42, 1915.

lite series covers a much larger area than any of the other sedimentary rock groups of the Port Valdez district. Its rocks grade from the conglomeratic graywackes at the bottom through gray to dark-gray coarse-grained graywackes containing feldspathic material, small slate fragments, and pebbles of older rocks of similar nature, to the darker, finer-grained argillites. The graywackes are the predominant members of the series. In places there are alternating beds of characteristic dark argillites and equally distinct graywacke, the individual beds being but a few inches thick. The contrasting colors of the argillites and graywackes in these occurrences give, at a little distance, a distinctly banded or ribbon-like appearance to the rock. Elsewhere the graywackes are in massive beds several hundred feet thick, with only an occasional thin bed of the argillite. The graywackes are composed of subangular fragments of quartz and plagioclase feldspar, comparatively little decomposed, and a few grains of epidote, in a carbonaceous, calcareous, and argillaceous matrix. Small fragments of earlier graywackes and cherts are also found in these graywackes.

QUATERNARY DEPOSITS.

The Quaternary deposits are the youngest sediments of the district. They consist of unconsolidated material resting unconformably on the glaciated surfaces of the metamorphic rocks and include glacial deposits, fluvioglacial deposits, the sands and gravels of the present nonglacial streams, lake deposits, beach deposits, talus cones and fans, and landslide material. These deposits have been formed by the erosion, principally glacial, of the metamorphic bedrock of the district and consist chiefly of graywacke and argillite, with minor amounts of slate, greenstone, green schist, aplite, and quartz. The district has been one of glacial erosion rather than of deposition, and the Quaternary deposits mask relatively small areas. Glacial till forms a thin patchy mantle over all the low-lying parts of the district. Fluvioglacial deposits have their best development in the united outwash plains of the Valdez Glacier streams and Lowe River, and glacially excavated rock basins filled with fluvioglacial gravels occur on Solomon Gulch and Mineral Creek. A concentric series of gravel terraces lies on the outer side of the big bend in Shoup Glacier between Shoup and Anderson glaciers. Landslide débris covers many acres between Solomon Gulch and Fort Liscum.

STRUCTURE.

The structure of the Port Valdez district has not been worked out, but certain general statements may be made regarding its broader features. The stratigraphic succession as at present understood has

been given above, and the areal distribution of the different formations is due largely to their deformation since they were laid down. The least-deformed beds are at the entrance to Sawmill Bay, bordering the upper reaches of Valdez Glacier, and at the head of Solomon Gulch. The Valdez Glacier area lies north of the second glacial tributary to Valdez Glacier from the east. Here a thick succession of graywackes and argillites strike approximately east and dip rather gently to the north. At the head of Solomon Gulch the folding has exposed a large mass of greenstone beneath the overlying graywackes. At Sawmill Bay the entire sedimentary series has been closely folded and faulted. The beds strike N. 40°–70° E. and dip 70° N. to vertical. Over the rest of the Port Valdez district a marked uniformity in the strike and dip of bedding and schistosity prevails. The strikes are between S. 70° E. and N. 75° E. and the dips are from 45° to 80° N. Minor folds observed at several localities indicate that the monoclinal dips are the result of closely compressed folds overturned to the south. In the western part of the district some of these folds were observed with axes having a westward pitch.

Subsequent to the folding, but before the mineralization of the rocks, a set of fissures was developed in which the gold-bearing quartz was later deposited. These fissures trend between N. 25° W. and S. 50° W., but most of them lie between N. 55° W. and west. This set of fissures dip between 65° and 90°, mostly to the north and east. Pronounced jointing trending from N. 45° W. to N. 30° E. is noticeable along the shores of Port Valdez but does not seem to occur around the mouth of Sawmill Bay.

INTRUSIVE IGNEOUS ROCKS.

GENERAL FEATURES.

Intrusive igneous rocks are not abundant in the Port Valdez district. A few small, widely scattered stocks or bosses of granitic rocks and a few dikes, of aplitic and diabasic types, are found. The relations of the diabasic dike rocks to the aplites and granites of the district are not known. The aplites and granites are probably genetically related to each other, and on the Giant Rocks, between the mouth of Mineral Creek and Valdez, a gradation can be seen from medium-grained granitic rocks to dense, finely porphyritic aplite dikes.

These intrusives are the youngest pre-Quaternary rocks of the district and intrude both the unaltered and the schistose phases of the sedimentary rocks. Their age is not known, but the granites and related dike rocks are probably of the same age as the other granitic intrusives of the Prince William Sound region, which in recent years

have been tentatively assigned to the Mesozoic. The igneous intrusions of the Port Valdez district apparently took place after the major deformations of the country rocks. In certain places, however, as in the Valdez Narrows, these igneous rocks have suffered later shattering and faulting. The granitic and aplitic rocks were intruded previous to the mineralization of the district and in many places show the effects of the hydrothermal alteration caused by the mineralizing solutions. Quartz stringers, with some calcite, occur in some of the diabase dikes, and in one place calcite and pyrite were seen along fracture and shearing planes in one of these dikes. As there is reason to believe that there was but one general period of mineralization in this district, it appears possible that some of the diabasic dike rocks were intruded previous to the mineralization, and it may be that some of them are complementary offshoots of the granitic magma.

GRANITIC AND RELATED ROCKS.

The granitic and related rocks of the Port Valdez district occur in small stocks or dikes on the Giant Rocks, between the mouth of Mineral Creek and Valdez; on the north shore of Port Valdez just west of the mouth of Gold Creek; on the east side of the entrance to Valdez Narrows; at the head of Solomon Gulch; on Mineral Creek; and within the valley occupied by Shoup Glacier. Abundant float is also found on the west lateral moraine of Valdez Glacier, and a granitic intrusive is reported in the west end of the Gold King nunatak. The rocks are all of light-grayish to light-greenish color and have fine-grained, porphyritic, or aphanitic texture. Surficial alteration of the mineralized phases gives the rocks a brownish cast. These light-colored rocks are intrusive into the dark-gray, green, and black metamorphic rocks of the district, to which they offer a marked contrast.

A boss of granitic rock with aphanitic to slightly porphyritic offshoots, 4 to 20 feet thick, occurs on the Giant Rocks, between Valdez and Mineral Creek. The dikes are intruded parallel to the schistosity of the surrounding metamorphic rocks, which here strikes about east and dips 55° N. The laminæ of the schists have in places been deformed by the intrusion of the molten rock, and the dikes show series of lenses of igneous rock varying in width from a quarter of an inch to 4 feet, around which the laminæ of the schistose rocks bend. Locally the dikes are badly sheeted and jointed. A little contact metamorphism, developing biotite in some of the surrounding graywackes, has taken place but is not common. The intrusives are medium-grained, finely porphyritic to aphanitic rocks of a light-gray to greenish-gray color. They are composed largely of plagioclase feldspar, with minor amounts of orthoclase, quartz, apatite, sericite, and ferromagnesian minerals. Biotite and chlorite are abundant in

some parts of the rocks. Sulphide mineralization of the intrusions is indicated by the scattered rusty spots in the weathered rock. Quartz seams, slightly iron stained, lie along some of the joints in the granite. Small quartz veins also cut the adjoining metamorphosed graywackes. The medium-grained, uniform-textured phases of this granite are used in the local rock-drilling contests at Valdez.

A badly shattered aplitic dike or stock is exposed for 125 feet along the eastern shore of Valdez Narrows, near the outer entrance. The rock is a light-gray dense aplite composed chiefly of quartz and albite. Ferromagnesian minerals are scarce. Pyrrhotite and chalcopyrite occur as impregnations in the aplite. Assays show the presence of a trace of gold. The adjoining graywackes appear slightly metamorphosed by the intrusion. A rock of similar appearance, mineralized by pyrrhotite, occurs at the head of Solomon Gulch, near the Midas mine.

A fine-grained light greenish-gray aplite dike crops out on the north shore of Port Valdez west of the mouth of Gold Creek. It is intrusive into the sediments parallel to the schistosity, which has a strike of N. 88° E. and dips 56° N. The dike is 4 feet wide and is traceable for about 150 feet along the shore. The dike exposure is much weathered and shattered. Small quartz veins are abundant in the graywacke near the dike.

The diabasic intrusive rocks are not as abundant as those of the other types and have been found only in the southwestern part of the district, on both sides of Valdez Narrows and in the mountains to the west. The rocks are dark colored and consequently are not conspicuous. They are dense, finely porphyritic or fine-grained diabases, some of which weather dark brown. Their width varies from 1 foot to as much as 25 feet, although the smaller dikes are the most abundant. They are usually vertical or nearly so. In some localities the dikes are shattered and slightly faulted. One diabase dike in the Valdez Narrows is impregnated with pyrite.

MINERAL RESOURCES.

INTRODUCTION.

The mineral resources of the Port Valdez district comprise deposits of gold, silver, and copper. At present gold and silver are the only metals recovered from the ores, but recent developments indicate that the Midas mine, on Solomon Gulch, will soon become a copper producer. A shipment of several tons of copper ore is said to have been made from this property in 1912 or 1913. The gold now produced in the district comes chiefly from gold quartz lodes, although a small amount of placer gold is obtained each year. These

placer operations are intermittent and on a small scale, and the output is very small. The silver occurs alloyed with the native gold of both lodes and placers. The copper ore of the Midas mine also carries both gold and silver. The gold ores are free milling, but the copper ores must be melted. Some of the gold quartz lodes contain chalcopyrite, but the amount is small and it is of no value. The concentrates from the gold-milling plants have been in the past and are at present shipped to smelters.

In the following discussions of the relations of the ore deposits, two types of ores, gold quartz ores and copper-bearing sulphide ores, are recognized. There is reason for believing that in the Valdez district, as in the Ellamar district, both types of ore had a common origin in the mineralizing solutions and were deposited in the same epoch of metallization. Differences in physical and chemical conditions existing at the place of deposition of the ores are believed to account for the present diversity in the types of deposit, inasmuch as the mineral associations at both gold and copper deposits are practically identical, only the relative amounts of the different minerals in the ores varying.

Auriferous gravels were known to occur in the streams of the Port Valdez district many years before any workable gold-bearing quartz was discovered. By 1898 Schrader[1] reported that pay gravels had been found on several of the streams and that some work had been done on them. Quartz veins were staked as early as 1897 in some parts of the district, and in 1901 the Midas copper deposit, at the head of Solomon Gulch, was located by H. E. Ellis. Valdez was, however, for a number of years after its settlement looked upon merely as a starting point for the interior, and it was not until after the Cliff mine, which had been located in 1906, became productive in 1910 that the mineral possibilities of this region began to be realized. As Brooks has stated,[2] the success of the Cliff mine—

> very greatly stimulated prospecting by local miners and attracted the attention of nonresidents, who quickly recognized the possibility of developing here a new auriferous lode district. As a result, several hundred lode claims were staked and considerable development work was undertaken during 1910 and 1911. These activities first centered in the region immediately adjacent to Port Valdez, but later both the eastern and western extension of what was believed to be an auriferous belt received attention. The search for auriferous lodes was carried westward to Columbia Glacier and later to Port Wells and eastward along the Valdez-Fairbanks road.

The Ellis Imperial had been located in 1909 by the discoverer of the Cliff. In 1910 the Ibex, Silver Gem, Gold King, Alice, Sealey-Davis, Millionaire, and Black Diamond claims and those of the

[1] Schrader, F. C., A reconnaissance of a part of Prince William Sound and the Copper River district, Alaska, in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 421–422, 1900.

[2] Brooks, A. H., Gold deposits near Valdez: U. S. Geol. Survey Bull. 520, p. 108, 1912.

Valdez Mining Co. were among those located. The next year (1911) some of the properties located were the Ramsay-Rutherford, Bald Mountain, Pinocle, Bessie Williams, Cameron-Johnson, Mountain King, Rambler, Big Four (on Mineral Creek), Mayfield, and Bunker Hill. The mining developments up to and including 1912 have been summarized by Brooks,[1] and those in 1913 by the writer.[2] Milling plants have been erected at properties on the east side of Valdez Glacier, on Mineral Creek, at the Cliff mine, on the west side of Shoup Glacier, and on a barren rocky island in Columbia Glacier, and a considerable output of gold now comes annually from these lodes. The extensive developments made on the Midas copper property by its present owners justify the assumption that it will soon not only add materially to the gold production of the Port Valdez district but also place the district among the copper-producing districts of Alaska.

In 1914 nine mills of various types were in operation in the Port Valdez district, and it is estimated that between 250 and 300 men were engaged in mining at one time or another during the year. The value of the total mineral production to January 1, 1915, has been about $900,000.

The valuable metal content of the gold quartz thus far mined in the Port Valdez district has averaged about $37 a ton. It has ranged from $18 to $85 in ores milled at the several prospects during an entire season, and still higher averages have been obtained on lots of a few tons sent to custom mills or smelters. The thickness of the veins thus far mined in this district has ranged from a few inches to more than 5 feet, but the average thickness of the ore bodies developed on producing properties appears to be between 1 and 2 feet. The greatest depth to which an ore body has been mined is about 500 feet, at the Cliff mine.

GEOGRAPHIC DISTRIBUTION OF ORE DEPOSITS.

The Port Valdez district is one of several scattered gold quartz districts on the mainland bordering Prince William Sound from McKinley Lake to Seward. These districts form a broad mineralized belt, concave southward, encircling the copper deposits of Prince William Sound, one of which (the Midas mine) is included within the Port Valdez district.

The area in which ore deposits have been found in the Port Valdez district lies in an east-west belt paralleling Port Valdez and extending from Columbia Glacier on the west to and beyond Valdez Glacier on

[1] Brooks, A. H., Gold deposits near Valdez: U. S. Geol. Survey Bull. 520, pp. 108–130, 1912; The mining industry in 1912: U. S. Geol. Survey Bull. 542, pp. 35–36, 1913.

[2] Johnson, B. L., Mining on Prince William Sound: U. S. Geol. Survey Bull. 592, pp. 237–239, 240, 1914.

the east, a distance of about 25 miles between the most easterly and most westerly known deposits. (See Pl. VIII.) Prospects have also been found in the vicinity of Thompson Pass and Ptarmigan Drop, 12 to 15 miles to the east, in what is apparently the eastward extension of the Port Valdez mineralized belt. Evidences of mineralization are also reported west of Columbia Glacier. The most northerly prospects within the area are those at the head of Mineral Creek, which are 8 miles from tidewater. The most southerly ore deposit is that of the Midas mine. The geologic limits of the gold-bearing area have not yet been definitely located. As Brooks[1] has shown, the inland limit of the occurrence of the ores seems to be determined by their accessibility, and the area outlined above and covered in this report "must in the light of present knowledge therefore be regarded as a topographic province in which ores have been found rather than as a geologic province within which the conditions for the occurrence of mineral deposits are more favorable than they are elsewhere." The actual limits of the mineralized area yet remain to be discovered, as it appears at present that they lie beyond the arbitrarily chosen limits of the Port Valdez district, which is only a part of a larger similarly mineralized geologic province.

Considerable prospecting has been done throughout the district, but as certain areas, such as the south side of Port Valdez, the area adjacent to Sawmill Bay, the lower part of Mineral Creek, and the upper reaches of Valdez Glacier, have shown little of promise, most of the development work has been confined to the area north of Port Valdez. Within that area there are several scattered areas in which promising ore bodies have been discovered. These are (1) on both sides of Valdez Glacier between Camicia Glacier and the next large eastern glacier tributary to Valdez Glacier; (2) the upper part of the Mineral Creek valley; (3) Shoup Bay and vicinity; and (4) the mountainous ridge between the upper reaches of Shoup and Columbia glaciers. To these should be added the area at the head of Solomon Gulch.

Gold-bearing quartz veins occur both north and south of Port Valdez, although, as pointed out above, those of economic importance thus far have been on the north of the bay. The only copper deposit occupies an isolated position near the head of Solomon Gulch on the south side of Port Valdez.

VERTICAL RANGE.

The known vertical range of mineralization is over 5,600 feet, extending from 300 feet below sea level in the Cliff mine to an elevation of 5,350 feet at the Big Four property on Mineral Creek. Gold

[1] Brooks, A. H., Gold deposits near Valdez: U. S. Geol. Survey Bull. 520, p. 119, 1912.

quartz deposits have been found throughout the vertical range of mineralization. The Midas mine is at an elevation of about 800 feet above sea level.

DISTRIBUTION OF PRODUCTIVE MINES.

The gold quartz producing properties all lie north of Port Valdez and Lowe River. The Gold King, the Cameron-Johnson, the mines at the head of Mineral Creek, and the Ramsay-Rutherford lie near the northern border. The Gold King is the westernmost producer, the Ramsay-Rutherford the easternmost, and the Cliff mine the southernmost. The Midas mine, a prospective producer of gold-copper ore, is south of Port Valdez. The Cliff mine, the earliest and largest producer of the district, is at sea level, but not all the producing properties are located on or near the coast. The Gold King, at an elevation of 3,750 feet on a nunatak in Columbia Glacier, is 6¼ miles in an air line from tidewater. The Mineral Creek properties are over 7 miles from the bay and range in elevation from 300 to more than 5,000 feet above sea level. The Ramsay-Rutherford property, 8 miles from the coast, is at an elevation of about 3,500 feet. The Rose Johnson mill, on Valdez Glacier, 6 miles from Valdez, is at an elevation of 1,200 feet. The Midas ore will have to be transported 4½ miles from the mine to ocean-going steamers. These productive properties may be grouped as follows: Valdez Glacier valley, 2; Mineral Creek valley, 4; Shoup Bay and vicinity, including the Cliff mine, 2; Columbia Glacier valley, 1; Solomon Gulch, 1.

GEOLOGIC RELATIONS OF THE ORE DEPOSITS.

STRUCTURE.

The determination of the limits of the mineralization of the Port Valdez district is largely a structural problem. Both the gold quartz and the copper deposits occur only in the more intensely disturbed areas. The distribution of the gold quartz deposits appears to depend largely on the occurrence of the thick series of fractured graywacke and argillite which, as previously pointed out, overlies the greenstones and black slates of this district. The folded and faulted beds of this series cover a large part of the Port Valdez district, interspersed with small infolded bodies of the greenstones and black slates. The gold quartz deposits occupy fissures in this disturbed series and in the metamorphic complex of which it forms so large a part. Certain areas appear to have been more favorable to the deposition of the gold quartz ores than others. There appears to have been an area of this character on Valdez Glacier near the Ibex and Ramsay-Rutherford properties, where this brittle series fractured on

the upper limb of an overturned fold. The deposits on Mineral Creek, which have not yet been carefully studied, appear to occupy a somewhat similar situation. Another highly fractured mineralized belt extends from Shoup Bay westward through the Anderson Glacier pass.

The Midas copper deposit is in a shear zone that traverses a portion of the area in which all the rocks of the local geologic section—black slates, greenstones, and graywackes—are involved in the deformation.

The strikes of the greater majority of the ore-bearing fissures of the district lie within the 105° included between N. 25° W. and S. 50° W. Within this arc there is a little closer grouping between N. 55° W. and west. The dips range from 65° to 90° and are mostly to the north and east.

The fissures are as a rule narrow. Some are sharp, clean-cut, and filled with quartz. Others are shattered zones largely filled with fragments of the country rock between well-defined walls, with lenses or irregular networks of quartz cementing the fractures. In still others the filling is pulverized and shattered country rock with little or no quartz.

Some postmineral movement has occurred within the mineralized district, resulting in the shattering of some of the quartz and the slight faulting of some of the veins.

No marked changes are to be expected in depth either in the mineral association of the ores or in the value of the lodes as a whole. It appears probable that gold quartz veins are distributed throughout the rocks to considerable depths in much the manner and form shown by the present known ore deposits. The persistence of the general mineralization with depth, however, is no criterion as to the persistence of the mineralization in individual deposits. The vein matter is usually not continuous along either strike or dip, even in fissures that are traceable for long distances. The ore occurs in narrow shoots that are lenticular in both plan and section, and the distribution of the shoots within many of the fissures is very irregular. The average width of the ore shoots thus far mined is between 12 and 24 inches. Their length has varied, attaining a maximum perhaps in the Cliff mine, where the ore has been followed from a point 200 feet above sea level to a point 300 feet below.

RELATIONS TO COUNTRY ROCK OTHER THAN STRUCTURAL RELATIONS.

The character of the country rock appears to have had little if any chemical effect on the deposition of the gold-bearing quartz lodes of the district, which have the appearance of simple fissure fillings and show no evidence of chemical action. The country rock of these veins, however, is in places impregnated with pyrite and

arsenopyrite. The copper deposits are impregnations and replacements of sheared rocks. In the Midas mine the rocks most closely associated with the ore are the black slates. In the Ellamar district the black slates include some impure dark limestones, and it is not at all improbable that much of the sulphide impregnation and replacement evident at the Midas mine are the result of the action of the calcareous sediments involved in the shearing of the black slate and greenstone series upon the mineralizing solutions.

CHARACTER OF THE LODE ORES.

As pointed out previously the mineral association in both gold and copper deposits is practically the same, the relative proportions of the different minerals alone varying. Both types of ores are composed of primary minerals. Classified on the basis of the dominant valuable metals, the ores may be grouped into gold-silver and copper-gold-silver ores. From a metallurgist's point of view the ores are classifiable into free-milling gold ores and base smelting sulphide ores with a high copper content. This also agrees with a classification based on the predominant minerals, which in one kind of ores are native gold and quartz and in the other are the sulphides chalcopyrite, pyrite, and pyrrhotite.

The mineralogy of the ores is fairly simple. The economically important minerals are native gold and chalcopyrite, the former being the source of the gold and silver and the latter the source of the copper. Quartz is the dominant gangue mineral of the gold quartz ores; calcite and a brown-weathering light-colored carbonate occur in less abundance, and albite and chlorite are present in some of the ores. The gangue of the copper ores is the crushed and altered country rock, with a very small amount of quartz and carbonates. The metallic ore minerals comprise gold, silver, pyrite, and stibnite. Pyrite is the most common and universally distributed sulphide, with galena a close second. Sphalerite and chalcopyrite are the next most widely distributed minerals, and some of the ores contain pyrrhotite and arsenopyrite. Stibnite was noted in ore from the Gold King and the Silver Gem. Limonite is the most common alteration product from the oxidation of both gold and copper ores, but malachite staining was also noted at the Midas. Surficial alteration products of arsenopyrite and stibnite are usually visible on surface exposures of ores carrying those minerals. In the gold quartz ores the amount of sulphides present is usually small.

In most of the ore deposits of the district the primary sulphides of the ores are exposed at the surface, although the outcrops of the ore bodies have in many places been modified slightly by the postglacial oxidation of the sulphides in the veins, and in the more favorable

places a slight partial oxidation of the sulphides has taken place to depths of at least 100 feet. A part of the gold formerly contained in the eroded parts of the veins appears to have been left behind in the partly oxidized outcrops, which in places show marked surface enrichment.[1] Brooks has placed the thickness of this enriched zone as less than 20 feet.

GENESIS OF THE LODE ORE DEPOSITS.

Genetically classified the Port Valdez gold quartz lodes are fissure fillings of hydrothermal origin formed at moderate temperatures. The copper lodes are due to the impregnation and replacement of sheared sedimentary strata by hydrothermal solutions at moderate temperatures. The mineral association in the copper and gold quartz deposits is similar. This is true also of the other copper and gold districts of Prince William Sound, where a gradation from a gold quartz vein to a chalcopyrite-bearing shear zone has been noted. A common origin from the same mineralizing solutions is therefore assumed for the copper and gold quartz ores of the Port Valdez district. The evidence indicates but one period of mineralization. The ores were deposited later than the deformation of the sedimentary rocks of the area and the consequent development of the schistosity around Port Valdez. The mineralization was also later than the intrusion of the granitic and related igneous rocks of the area, inasmuch as the granites on the Giant Rocks, between Mineral Creek and Valdez, and the aplites of Solomon Gulch and Valdez Narrows were mineralized subsequent to their intrusion. A more definite determination of the age at which the mineralization took place is not obtainable from this district. The granitic intrusions of Prince William Sound and presumably those of the Port Valdez district also are probably of Mesozoic age. In most Alaskan metalliferous districts an intimate relation has been shown to exist between the ore deposits and intrusions of granitic character. In the Port Valdez district the presence of albite in the gold quartz veins indicates that the vein-forming waters had a magmatic source from granitic igneous rocks. These waters circulated subsequent to the granitic intrusions, to which, therefore, they were most probably genetically related. The ore deposits of the Port Valdez district, if these conclusions are justified, are all of Mesozoic age and belong in the late Mesozoic metallogenetic epoch of the Pacific coast.

GOLD PLACER DEPOSITS.

The unconsolidated deposits of the Port Valdez district, being derived from the erosion of an auriferous series of rocks, are slightly gold bearing, and colors of gold are reported in the gravels on

[1] Brooks, A. H., Gold deposits near Valdez: U. S. Geol. Survey Bull. 520, p. 129, 1912.

streams entering Shoup Bay, Mineral and Gold creeks, Solomon Gulch, and Lowe River. Small amounts of gold have been recovered by intermittent operations on these streams. The unconsolidated deposits cover a comparatively small part of the district and are predominantly of glacial and fluvioglacial origin. Morainic material, talus deposits, and outwash fans or deltas from aggrading glacial streams present in general decidedly unfavorable conditions for paying placer ground, although exceptional cases undoubtedly exist. The processes involved in the deposition of these materials are such as would tend to disseminate widely any contained gold. Most of the streams of the Port Valdez district are still aggrading glacial streams, and while their gravels are auriferous in places they are probably of low grade and the gold is widely disseminated. Very little postglacial erosion of these glacial and fluvioglacial materials, which would tend to concentrate their gold content, has taken place, except in a few scattered localities on Gold, Mineral, and McAllister creeks. Postglacial erosion of bedrock in box canyons is a possible source of a small amount of the gold on some of the creeks. No large areas of commercial placers are known within the district, and the general conditions appear unfavorable for large workable placer deposits.

MINES AND PROSPECTS.

GENERAL ORDER OF STATEMENT.

The mine and prospect descriptions are grouped by drainage areas so far as this is possible, and these areas are treated in geographic order from east to west. (See Pl. VIII.) The properties near Valdez Glacier, on the east, are described first, and the properties near Columbia Glacier, the westernmost in this district, are described last. The arrangement of treatment within a given area has no significance as to the relative importance of the separate mines or prospects, nor is the amount of space devoted to a prospect any measure of its economic value. All the prospects in the Port Valdez district have not yet been visited, but information about some of the properties not examined has been procured from reliable sources and is here included. Several properties which were not visited in 1913 or 1914, and regarding which no recent information is available, were described by Brooks[1] after a visit to the claims in 1911.

VALDEZ GLACIER AREA.

MINE OF RAMSAY-RUTHERFORD GOLD MINING CO.

The Ramsay-Rutherford property is about 8 miles in an air line northeast of Valdez, on the ridge east of Valdez Glacier, between

[1] Brooks, A. H., op. cit., pp. 122–128.

Camicia Glacier and the next higher large glacier tributary to Valdez Glacier from the east. It is far above timber line, at an elevation of about 3,500 feet, in the west wall of a cirque tributary from the south to the large Valdez Glacier tributary above mentioned. The property is reached from Valdez by way of Valdez Glacier to a point 4 miles from the foot of the glacier and thence over a well-marked trail which angles up the east wall of the Valdez Glacier valley to the cirque in which the mine is located. The distance from Valdez to the mine by the traveled route is about 10 miles. The present workings are on the Lost Hopes Nos. 1 and 2 claims. Development was in progress in 1912–1914, and in October, 1914, the underground workings comprised a 162-foot shaft, 300 feet of drifts, 190 feet of crosscuts, and stopes between the 50-foot level and the surface. A small shipment of ore is reported to have been made during 1912 or early in 1913. In September, 1913, the Ramsay-Rutherford Gold Mining Co. was formed, and in the spring and summer of 1914 a 7 by 9 inch Blake crusher, a 5-stamp mill, and a concentrator were installed in a mill building near the mine and the mine and mill were connected by short ground and aerial trams. The mill, air compressor, machine drills, and pump were operated by five gasoline engines. The plant was also electrically lighted during the operation of the mill. The stamps are reported to have dropped first on August 4, 1914. Milling operations stopped September 16, 1914, because the canvas water pipes supplying the mill froze. Besides the mill building a cookhouse and a bunk house were erected at the mine. A maximum of 27 men were employed during the operation of the mill. After the mill was shut down this force was decreased to 10 men, and during the winter of 1914–15 the mine force is said to have been reduced to 3 or 4.

The country rock, chiefly graywacke with a little argillite, strikes about east and dips 75° N. To the north the dips are gentler, and across the large tributary to Valdez Glacier north of the Ramsay-Rutherford property the graywackes appear to dip north at a low angle.

The ore bodies on the Ramsay-Rutherford property are fissure veins. On the 50-foot level the vein upon which the underground development work has been done ranges in width from 1 inch to 72 inches, in strike from S. 1° E. to S. 25° E., and in dip from 82° E. to 70° W. On the 100-foot level the strike is S. 35°–45° E., the dip is 82° E., and a maximum width of 6 feet of quartz is exposed. The vein here varies in width from 1¼ to 5 feet, with an average width of 2½ to 3 feet. This lead is stripped for over 50 feet on the surface, where it strikes S. 30°–40° E. and dips 80° E. In some places the vein is solid quartz; in others it contains considerable brecciated country rock. Bunches of solid sulphides, chiefly pyrrhotite, are

reported in the solid quartz on the 100-foot level. A fault that cuts off the vein in the north end of the 50-foot level has a strike of S. 80° E. and a dip of 80° N. About 5 inches of gouge occurs on the fault plane, and gouge also shows in places on the walls of the vein. Post-mineral movement along the vein is indicated by the badly shattered and crushed quartz in some parts of the vein.

A surface open cut on what is considered a second vein exposes a reported maximum width of 11 feet of ore. This vein is said to be traceable for 60 feet and to average 3½ feet in width.

The ore is a free-milling gold quartz accompanied by sulphides in very subordinate amounts. The ore milled in 1914 averaged less than 1 per cent of concentrates. In portions of the vein, however, the sulphides are much more abundant, and in some places bunches of nearly solid sulphides, chiefly pyrrhotite, occur in the white quartz. The minerals present in these sulphide masses are the same as those disseminated in the rest of the vein. The principal gangue mineral is quartz; calcite and probably siderite occur sparingly. The gold is native and was observed most abundantly in the sulphide bunches. Silver is also present in the ore, probably alloyed with the gold. Pyrrhotite, pyrite, chalcopyrite, sphalerite, and galena are the sulphides present. Arsenopyrite is reported, but none was seen by the writer. Limonite occurs as a surficial oxidation product of the iron-bearing sulphides.

PINOCHLE CLAIM.

The Pinochle claim, on the westward-facing slope of the same mountain as the Ramsey-Rutherford mine but a little nearer Valdez, is reached by the same route. The claim is above timber line, at an elevation of about 3,100 feet. The development work in September, 1914, consisted of a short tunnel on the vein, a 115-foot crosscut tunnel driven to tap the lode at about 90 feet in depth, a 10-foot shaft on the supposed extension of the ore fissure, and some stripping along the vein. Three men were at work on the property in the later part of September, 1914.

The country rock of the ore deposit consists of closely folded graywacke and argillite, striking, at the mouth of the adit, N. 67° W. and dipping 86° N. The ore body occupies a well-defined fissure reported to be traceable on the surface a distance of 110 feet. The lead strikes N. 30°–60° W. and is practically vertical. The width of the fissure ranges from 4 to 36 inches. The quartz content of the fissure also varies widely, very little being evident at some places, while at others 3 feet of solid quartz fills the fissure. One large quartz lens 3 feet thick and traceable along the roof of the tunnel for 15 feet was observed. In the face of the crosscut tunnel in September, 1914, there was a small vertical shear zone, 4 to 12 inches

wide, striking N. 85° W., which in the floor showed a width of 12 inches of quartz. The gangue of the ore from this property is a white quartz. Pyrite was the only sulphide recognized in the ore.

CLAIMS OF VALDEZ MINING CO. AND IBEX GROUP.

Brooks[1] in 1911 visited the claims of the Valdez Mining Co. and also the Ibex group. His descriptions follow:

The Valdez Mining Co. owns a group of claims on the west side of Valdez Glacier about 8 miles from tidewater, at an altitude of about 2,700 feet. It can be reached from Valdez by a horse trail which traverses the glacier for some distance. The country rock consists of interbedded schistose graywacke and slate, which strike about N. 75° E. and dip about 75° N. The vein, which at the outcrop is about 5 to 6 feet wide, strikes about N. 60° W. and dips 70° S. An adit, which reaches the vein at a depth of about 60 feet, has been driven 110 feet. A winze has been sunk 50 feet below this level, at which depth a drift has been run on the vein for some 40 feet. The vein at this depth is well defined, having good walls and a gouge on the hanging wall. The vein is from 3 to 8 feet wide in the underground workings. It is made up of ribbon quartz, which carries the gold in high values and measures from 2 to 4 feet in thickness, and of massive white quartz. On the lower level the ribbon quartz is from 24 to 50 inches wide. The white quartz also carries some gold. The ribbon quartz includes coarse pyrite masses and crystals. The vein includes druses containing well-developed quartz crystals. Another adit, which has been driven about 115 feet, is intended to crosscut the vein at a depth of 330 feet in a distance of 300 to 325 feet.

The Ibex group of claims lies about one-fourth mile northwest of the Valdez tunnel, where a 4-foot vein outcrops at an altitude of about 2,600 feet. Both walls of this vein are well defined. Banded quartz in this vein is said to carry gold in high values. A tunnel has been driven about 200 feet, but the vein was lost at a distance of 100 feet. The Ibex vein is believed to lie on an extension of the Valdez.

The Valdez Mining Co. in 1913 continued its crosscut tunnel to a length of about 230 feet.

ROSE JOHNSON PROPERTY.

The Rose Johnson claims are on the east side of Valdez Glacier about midway between Camicia Glacier and the next large tributary to Valdez Glacier from the east. A 1-stamp mill was erected in 1914 on one of the claims, at an elevation of about 1,200 feet. The milling equipment is said to include also a small crusher and a water wheel. The mill was run only a short time in 1914. The underground developments on this group of claims are reported to consist of several short tunnels, a 20-foot shaft, some open cuts, and stripping.

The country rock at the mill consists chiefly of crinkled and sheared black slate associated with considerable greenstone. The schistosity in the slate strikes about S. 85° E. and is vertical.

[1] Brooks, A. H., Gold deposits near Valdez: U. S. Geol. Survey Bull. 520, pp. 127–128, 1912.

Operations had stopped and there was no one on the property at the time it was visited. A vein in slate in one tunnel strikes S. 85° E., has a vertical dip, and shows a width of 2 to 7 inches of quartz. The other ore bodies were not seen, but they are reported to range from 6 inches to 3 feet in width. Specimens of ore said to come from this property show free gold, pyrite, galena, chalcopyrite, and sphalerite (?) in a quartz gangue. Some limonite has been formed by the surficial oxidation of the iron-bearing sulphides.

MINERAL CREEK.

The mines and prospects on Mineral Creek were visited by George L. Harrington, who wrote the following descriptions:

MOUNTAIN KING PROPERTY.

The Mountain King property of W. L. Smith is on the east side of Mineral Creek, a mile east of the mouth of Brevier Creek, at an elevation of about 3,000 feet. There are four tunnels on the property. The upper one, about 10 feet long, was driven till it cut the vein, when the ore shoot was stoped out. This tunnel has now caved in. About 40 feet below it are the workings from which ore is now being taken, consisting of a 100-foot tunnel, and at the end of it a 45-foot drift and a stope above the drift, along the vein. The vein is irregular in width, ranging from 1 inch to 18 inches, and consists of somewhat lenticular masses of quartz, joined by quartz stringers. The tunnel is driven N. 50° W. through sheared and platy graywacke, which strikes approximately east and dips steeply to the north. The metallic minerals are pyrite, galena, chalcopyrite, sphalerite, and free gold. The pyrite has weathered and oxidized, staining the quartz with iron oxides.

A third tunnel about 50 feet below this opening has been driven 85 feet N. 2° E., cutting the vein, along which a drift has been run for 40 feet. This drift exposes the vein for about 15 feet, where it shows a width of as much as 18 inches of iron-stained quartz that contains some sulphides. The bunk house and blacksmith shop are at the mouth of this tunnel. A fourth tunnel driven 135 feet below the bunk house to intersect the vein is said to be in 260 feet.

During the summer of 1914 the mill, on Mineral Creek just below the mouth of Brevier Creek, has been in operation, putting through over 120 tons. This mill was built during the previous summer and winter and consists of a 10 by 12 inch crusher, a stamp mill of two 1,200-pound stamps with plates, a table, a Pelton wheel operating under a 160-foot head, and a small generator. The ore was brought about halfway down the slope to the mills by go-devils and the rest of the way by double-ended sleds lowered by a donkey engine, with

a short length of aerial tram at the mill. A survey has been made for the installation of an aerial tram from the mill to the lowest tunnel.

Development work, consisting of about 200 feet of tunnels, is said to have been done on other claims under the same ownership, lying north and east of the Mountain King claim and farther up the ridge, but these were not visited. Essentially the same minerals are reported, with the addition of arsenopyrite from the claim lying to the north.

WILLIAMS-GENTZLER PROSPECT.

The Williams-Gentzler prospect is on the north side of the East Fork of Mineral Creek, at an elevation of about 4,000 feet. It was not visited. The work done is reported to consist of an upper tunnel about 30 feet long, a lower crosscut tunnel to the vein about 25 feet long, and a drift on the vein about 30 feet long. There is a shaft 12 feet deep in the lower tunnel. During the summer of 1914 a raise was driven to connect the two tunnels. The ore was treated in an arrastre, 10 feet in inside diameter, four drags of 200 pounds weight being used, running at 5 to 6 revolutions a minute. The power used was furnished by a 2½-horsepower gasoline engine. The ore was crushed by hand to a size suitable for the arrastre. The capacity was about 2 tons in 24 hours. A portion of the concentrates was saved by riffles.

The ore shoot pitches to the southeast and extends about 25 to 30 feet, though the vein is traceable much farther. Minerals reported in the ore are pyrrhotite, pyrite, and galena.

BIG FOUR CLAIM.[1]

The upper workings on the Big Four claim lie at an elevation of over 5,000 feet. It is reported that the tunnels on this claim aggregated about 200 feet in September, 1914, but the claim was not visited.

Some work has also been done on a second vein, at an elevation of 3,900 feet, consisting of 135 feet of tunnel and about 25 feet of stripping along the vein. This vein shows a maximum width of 3 feet of shattered iron-stained quartz, containing considerable amounts of pyrite, some galena, sphalerite, and free gold. The vein is exposed for about 20 feet in the tunnel, where it strikes N. 75° W. It shows at least one offset along a plane parallel to the principal joint system (N. 15°–20° E.), and the two portions of the vein are apparently connected by barren quartz stringers along this line of offset.

During the spring and summer of 1914 a mill and a bunk house were erected and machinery installed in the mill, the equipment consisting of a small crusher, a 10-stamp mill, with amalgamating

[1] Brooks, A. H., op. cit., p. 125.

plates, and a 12-horsepower distillate engine. The mill was in operation during September and October, 1914, test runs being made on ore from both the upper and lower veins. The ore is brought down by sleds or go-devils from the upper tunnel to the lower tunnel, and a 650-foot aerial tram handles it from this point down to the mill.

PROSPECTS OF MINERAL CREEK MINING CO.

The prospects on which work has been done by the Mineral Creek Mining Co. include the Buster, Chesna, Hercules, Millionaire, and Sunshine claims, all of which lie on the west side of Mineral Creek.

The work done on the Buster vein consists of a tunnel 200 feet long which follows the vein for 25 feet, to a point where it pinches. It is encountered again farther in, and a shallow winze is sunk on it. At the portal of the tunnel there is a shattered zone about 3 feet wide containing about 18 inches of quartz, in a country rock of sheared argillite and graywacke. Pyrite was the only sulphide seen.

There are three tunnels at the Chesna with a total length of about 750 feet. Only the upper and lower tunnels were examined. The lower tunnel is about 180 feet long and is driven N. 40° W. on a few quartz stringers 2 to 3 inches wide, separated by 6 to 8 inches of graywacke. The quartz is iron stained and shows a small amount of pyrite and carbonate. The upper tunnel has about 200 feet of drift and 20 feet of crosscuts. It is driven on a 4-foot shear zone carrying as much as 2 feet of quartz. This zone pinches within about 50 feet but widens out (or a new lead is encountered) farther along in the tunnel. The only metallic mineral seen was pyrite. The country rock at the mouth of the tunnel is a much-sheared slate. In the tunnel the rock is a slaty graywacke. The middle tunnel is said to include about 350 feet of drifts and crosscuts.

On the Hercules claims 120 feet of tunnel with 115 feet of crosscuts and two shallow winzes sunk on the vein constituted the development work up to 1914. The assessment work for 1914 was being done by driving a tunnel about 100 feet lower down, to intersect the vein at an estimated distance of 250 feet. About 10 feet of this tunnel had been driven early in October. The strike of the schistosity of the graywacke is N. 80° W. and the dip 65°–70° N. The vein follows the country rock closely in dip and strike. It has a maximum width of 20 inches in the main tunnel, but as indicated on the roofs of the crosscuts it seems to pinch in both directions. The minerals of the vein include quartz, gold, pyrite, galena, sphalerite, chlorite, carbonate (mostly lime), pyrrhotite, and chalcopyrite(?).

There are two tunnels on the Millionaire claim. The upper tunnel was driven about 60 feet to cut the vein and about 20 feet along it. In addition a winze was sunk on the vein about 50 feet, and the vein

was stoped out above to a height of about 15 feet. The ore taken out contains pyrite, pyrrhotite, chalcopyrite, and galena and shows also some thin plates and flakes of free gold. The vein, as exposed in the workings, strikes N. 60° W. and dips 70° N. It has a width of 6 to 20 inches. The lower tunnel, 100 feet below, was driven on a shear zone containing numerous quartz stringers with a small amount of pyrite, but only a little gold is reported from this zone. This tunnel is about 450 feet long.

HIGH GRADE PROSPECT.

The High Grade prospect lies in the canyon of Mineral Creek about a mile above McIntosh's road house. Two tunnels have been driven on the property. The one on the west side, which was not visited, is said to be 140 feet long; the tunnel on the east side is in 60 feet. A fair trail to the mouth of the canyon connects the prospect with the wagon road down Mineral Creek.

The country rock is a schistose graywacke, and the tunnel on the east side is driven on a 3-foot shear zone made up of this rock and shattered quartz, the quartz in places amounting to 6 or 8 inches. At the face the shear zone is about 1 foot wide. The metallic minerals are pyrite and galena, with quartz and a brown-weathering carbonate as the gangue. Much of the gold is said to lie in the sulphides.

The opening on the west side of the creek is driven on a quartz vein said to be 8 inches wide in places, and it is asserted that the vein and fissure are traceable for half a mile or more. The minerals are essentially the same on both sides of the canyon.

"45" PROSPECT.

The prospect known as the "45" is on the south side of Brevier Creek, at an elevation of about 2,500 feet. The work on the claim was done in 1913 and consisted of about 20 feet of tunnel and an open cut of about 20 feet, with a 16-foot face. The tunnel is driven on joint fractures striking S. 45° E. and dipping about 70° E. The principal fracture is from 1 inch to 6 inches wide, averaging about 4 inches, filled with crystalline quartz, generally iron stained, in some places containing lenses of pyrite as much as 6 inches in diameter and half an inch or more in thickness. In the face of the tunnel is a 6-inch seam of slaty gouge which carries very little quartz. The metallic minerals present are pyrite, galena, sphalerite, chalcopyrite, and free gold. Quartz is the dominant gangue mineral.

The country rock is graywacke, whose schistosity strikes N. 80° E. and dips about 70° N. Numerous joint fractures parallel to that on which the tunnel has been driven occur, many of these showing 2 inches or less of porous iron-stained crystallized quartz.

The assessment work for 1914 was done by the construction of a trail from the mouth of Brevier Creek to an elevation of about 1,700 feet, above which, on account of the gentle slope, free from brush, no trail is necessary.

VON GUNTHER PROSPECT.

The prospect of Dr. O. von Gunther lies on the west side of Mineral Creek near the end of Mineral Creek Glacier, at an approximate elevation of 1,320 feet. The development in September, 1914, consisted of 18 feet of tunnel driven along the fissure, which trends N. 47° W. At the portal of the tunnel about 2 feet of quartz shows along the wall. At the working face no quartz shows along the graywacke wall rock, but there are a few 2-inch clear-white quartz stringers cutting across the face. The vein is nearly vertical as seen along the outcrop and appears for about 20 feet both vertically and horizontally, being covered by talus below the mouth of the tunnel. The ore minerals consist of pyrite and its oxidation products. The gangue minerals are quartz and calcite. Claims have been staked on a wider vein in the creek bottom that is believed to be an extension of this vein.

QUITSCH PROSPECT.

The prospect of William Quitsch consists of one claim on Mineral Creek Glacier about 2½ miles from the front of the glacier. It was not visited. In 1913 a trail was built to the property, and it is reported that in 1914 about 12 feet of tunnel was driven. Specimens of ore said to come from this prospect show quartz, galena, pyrite, some of the products of oxidation of the pyrite, and a small amount of free gold. The vein occurs in graywacke.

HICKEY PROPERTY.

In August, 1914, the property on the east side of Mineral Creek half a mile east of Brevier Creek, formerly known as the Mountain View claim[1] of the Mineral Creek Mining Co., was restaked by Ross Hickey, but no development work had been done October 1, 1914. The previous owners had stripped the quartz ledge upon which discovery was made for about 30 feet. At one place on the ledge as then exposed numerous specks of free gold were discernible. On this face there was also a considerable amount of pyrite and a little galena, the pyrite oxidized and staining the quartz. The vein is from 8 inches to 3 feet wide, and some 2 to 3 inch quartz stringers extend into the hanging wall to the north. The vein crosses the east-west schistosity of the graywacke country rock at an angle of about 45°. The graywacke is platy, cleaving with irregular, rounded surfaces.

[1] Brooks, A. H., Gold deposits near Valdez: U. S. Geol. Survey Bull. 520, p. 126, 1912.

In the workings below the point of discovery the vein is exposed for about 150 feet, varying in width from 1 to 20 inches. The quartz carries very few sulphides.

MINERAL KING CLAIM.

The Mineral King is one of the claims formerly owned by the Mineral Creek Mining Co. The tunnel is on the south side of Brevier Creek, about a quarter of a mile from its mouth.[1] In September, 1914, the tunnel mouth had been covered by a slide. No work had been done during the current year.

MONTE CARLO PROSPECT.

The Monte Carlo prospect, better known as the Cook & Barrett property, lies on the west side of Mineral Creek at an elevation of 3,600 feet, about 1½ miles northwest of the mouth of Brevier Creek. The property is reached by a trail from the mouth of Brevier Creek by way of Millard's upper camp.

The earliest work done here was on a tunnel that was driven 110 feet in to cut the vein, and then an incline was driven about 36 feet farther without reaching the vein.

During the summer of 1914 a second crosscut tunnel was driven 36 feet at an elevation about 70 feet above the lower tunnel. This tunnel has reached the vein but has not been driven through it. The country rock is a schistose graywacke striking N. 70° E. and dipping about 70° N., and the vein upon which work is being done is approximately parallel to this in strike but has an irregular dip, there being some indication of a fold or roll in it. This vein has a maximum thickness of 5 feet. It is an offshoot of a larger vein that is exposed in a small gully for about 200 feet and has a maximum width of 15 feet. The larger vein contains a small amount of pyrite. From surface cuts on the small vein, which shows pyrite, galena, and free gold, 4 tons of ore was taken to Valdez in 1913.

CLAIMS OF H. L. JAYNES.

A group of claims was staked in 1913 and 1914 by H. L. Jaynes on the east side of Mineral Creek opposite the mouth of Brevier Creek, at an elevation of about 2,800 feet. The claims include the Rose, July, and Little Giant. The work done on the Rose and July claims consists of stripping and the building of trails. On the Little Giant some surface stripping has been done and in addition 46 feet of tunneling and 75 feet of crosscutting. The country rock is a graywacke with slaty cleavage that strikes about east and has a steep but varying dip to the north.

[1] Brooks, A. H., op. cit.

A quartz vein at the east end of the Rose claim is said to have been stripped for 40 feet to a depth of 8 feet, showing a width of 1 to 18 inches of quartz. The strike of this vein is N. 85° W. About 200 feet below, to the west, what is apparently the same ledge is exposed for about 200 feet and has a width of 4 to 12 inches. A crosscut tunnel 36 feet long is said to tap the vein at a depth of 40 feet. About a ton of ore was milled in Valdez in 1914 from this vein. It shows considerable pyrite and some galena and free gold. At the west end there is less sulphide and no free gold was seen, and lower assays are reported from this part of the vein.

On the July claim the vein has been stripped for about 25 feet, exposing from 6 to 10 inches of porous crystallized iron-stained quartz, showing pyrite, galena, sphalerite, and free gold. The vein strikes about N. 45° W. on the west end but swings to an approximate easterly direction on the east end.

There are two veins about 30 feet apart on the Little Giant, striking east, with the country rock, but apparently running together toward the east, the junction on the surface being in a small stream passing across the claim. These veins range from 6 inches to 4 feet in thickness and show varying amounts of the sulphides pyrite, galena, sphalerite, and pyrrhotite, as well as some free gold. Some carbonates are also present. The southern vein of the two is exposed on the surface for 40 feet and is 2 to 3 feet wide. About 200 feet to the west another vein or a continuation of one of the two mentioned crops out for 30 feet and shows from 1 inch to 8 inches of quartz, with pyrite, galena, and free gold. Several tons of ore from the surface croppings of the two veins on this property was milled in Valdez in 1914.

OTHER CLAIMS.

A large number of claims lie on the east side of Mineral Creek, mostly to the south of Wood Creek. These include the Alaskan, Hecla, Queen of Sheba, Tiger, the property formerly known as the Olsen & Wood, and several other claims.

On the Alaskan claim there is a 17-foot shaft, now nearly filled with water. This shaft is sunk on the vein, which is from 6 inches to 5 feet wide along 150 feet of outcrop. The general strike is about S. 77° E., and the dip ranges from vertical to 60° N. A small Z-shaped fold appears in the outcrop of this vein. The country rock is a sheared graywacke, and the vein minerals are quartz, pyrite, galena, sphalerite, chalcopyrite, and free gold. A second vein which crops out on this strike about 200 feet to the east may be a continuation of the first vein. A tunnel is being driven to cut this vein at an estimated distance of 500 feet from the portal. The tunnel is now said to be in 200 feet.

The Queen of Sheba tunnel is driven N. 58° W. for 36 feet on a vein which ranges in width from 1 foot to 6½ feet. The dip of the vein is vertical in general but wavy. The walls are well defined and free. The vein matter is shattered iron-stained quartz containing only a small amount of pyrite. The vein is exposed on the surface for about 60 feet.

In Wood Canyon on the Hecla claim there are two tunnels said to be 76 and 65 feet in length. The upper tunnel is driven on a quartz ledge which shows a maximum width of 6 feet and a vertical exposure of 150 feet. Both tunnels are driven on well-defined breaks about 300 feet apart, and in the shattered zone between the two veins are numerous stringers of quartz that widen out in many places to lenticular masses 2 feet across. In this zone are some black graphitic slates. A large part of the zone contains pyrite in the shattered graywacke and slate.

The Tiger claim lies down Wood Creek from the Hecla, and a 10-foot tunnel has been driven on it. There are numerous shear zones carrying as much as 2 feet of pyritized black slaty gouge, which contains many stringers of quartz. The more massive beds of graywacke show plication. The tunnel on the Olsen & Wood claim[1] is reported to be 200 feet in length. It is being driven to intersect a 4-foot shear zone containing many quartz stringers irregularly distributed through the zone. A trail was constructed in 1914 from McIntosh's road house to the cabin, which is at an elevation of about 1,600 feet.

VICINITY OF SHOUP BAY.

CLIFF MINE.

The Cliff mine is at sea level on the north side of Port Valdez, 10 miles from Valdez. It is at the base of a steep bluff at the east end of the gravel flat, half a mile east of Shoup Bay. A long wharf extending into deep water was formerly a stopping point for ocean steamers. The mine is reached from Valdez by gasoline launches.

The Mystic No. 1 claim, upon which the development work has been done, was located by H. E. Ellis August 15, 1906. In August, 1909, it was leased to the Cliff Mining Co., a local organization. The property has been systematically developed since that date. In the spring of 1910 a 3-stamp mill was installed and the mine became the first gold quartz producer of the Port Valdez district. In August, 1910, the underground developments consisted of two adits at a vertical interval of 54 feet, connected by raises, and one intermediate drift. The lower adit was about 200 feet long. There was also a short prospect tunnel about 200 feet above the beach. In 1911 the

[1] This claim was visited by Mr. Brooks in 1911. See Brooks, A. H., op. cit.

3-stamp mill was burned, but a new stamp mill was erected and in operation before the end of the year. Meantime mining operations were continued and the ore was shipped to Tacoma. The mine workings had reached a depth of 100 feet below sea level and extended for about 600 feet along the vein. In 1912 the 500-foot level, which is about 300 feet below sea level, was reached and some drifting was done on it. The Cliff mine was in 1913, as before, the largest producer in the Valdez district. The mill, with six stamps, was operated, except for short stops of some of the stamps, throughout the year. About 45 men were employed. The underground developments were reported to amount to at least 8,000 feet, of which over 900 feet was said to be on the 500-foot level. Development work was carried forward on this level until it was stopped by an influx of sea water. The pumps were then pulled and the water allowed to rise within a few feet of the 300-foot level. In the fall of 1913 mining and development work was in progress on the 100, 200, and 300 foot levels and in the stopes between them. The plant at that time included a jaw crusher, six stamps, three tables, boilers, an air compressor, drills, and hoists. Coal was used as fuel. In 1914 all operations at the Cliff ceased on July 6, and in August the property was turned over to the original owners. In the fall the water in the mine stood just below the 200-foot level.

The country rock of the ore deposit appears to be chiefly a dark-gray schistose graywacke, the schistosity of which in this vicinity strikes east and dips 65° N. Adjacent to the vein this schistose rock is highly impregnated with pyrite and small acicular crystals of arsenopyrite and cut by small mineralized quartz veins.

The Cliff ore body occupies a linked vein system which cuts across the foliation of the schistose graywacke. Present developments indicate that within the fractured zone of the mine there are several persistent fissures which fork, inclose large lenticular masses of country rock, and reunite along the strike without crossing one another. So far as present developments have gone these veins appear to diverge in depth. The general strike of this fissure system is N. 30°–40° W., although individual strikes range from N. 28° W. to N. 47° W. The dips of the fissures range from 65° E. to 48° W. in the upper levels of the mine. Below the 300-foot level the dip of the veins developed steepens to 85° W. On the outcrop and on the 100-foot level but one simple fissure occurs, and it has a dip of about 70° W. Between the 100 and 200 foot levels, north of the shaft, this vein splits. On the 200-foot level the two veins thus formed are 44 feet apart at the crosscut which connects them 160 feet north of the shaft, but they approach each other southward along the level. They dip in opposite directions. On the 300-foot level three veins are reported, the third

vein splitting off from the main fissure at the shaft about 25 feet below the 200-foot level. No data are available at present regarding the number of veins on the lower levels.

The fissure system has been traced underground along the strike for a distance of about 900 feet. The fissures are usually well defined. Their width is generally from 6 to 36 inches but locally increases to 5 feet. On the 300-foot level an average width of 1 foot of ore is reported. In some places there is only an inch or so of gouge in the fissure; in others the entire fissure is filled with quartz, or the sheared and shattered fissure filling may contain but a few quartz stringers. In the wider places a network of quartz stringers may occur, separated by masses of country rock. On some of the fissures barren stretches of many feet occurred between the ore shoots. Most of the ore came from the bayward end of the fissure system, and this shoot is said to have pitched to the southeast under the waters of Port Valdez.

The ore from the Cliff mine is a peculiar bluish-white quartz with minor amounts of calcite, albite, chlorite, and a brownish-weathering carbonate. The metallic minerals in the ore include gold, arsenopyrite, pyrite, sphalerite, and galena. The sulphides are mostly fine and do not appear abundant, but from milling operations the ore is estimated to contain from 3 to 5 per cent of sulphides. The ore is free milling. Gold was found on all the levels and is a primary constituent of the ore, occurring native in the quartz in association with the above-named sulphides. Pyrite and arsenopyrite appear most abundantly as impregnations of the graywacke country rock. A rather conspicuous characteristic of the Cliff ore, besides its bluish-white color, is the abundance of small acicular crystals of arsenopyrite sprinkled through the graywacke adjacent to the veins. Limonite occurs as a surficial oxidation product of the iron-bearing sulphides.

CLAIMS OF CAMERON-JOHNSON GOLD MINING CO.

The claims of the Cameron-Johnson Gold Mining Co. are on the right side of Shoup Glacier, on the mountain ridge between Shoup and Columbia glaciers. The mill and lower camp stand at an elevation of about 2,400 feet, or 900 feet above Shoup Glacier. They are about 4 miles in an air line from Shoup Bay and about 7 miles by trail from the head of the bay by way of Shoup Glacier. One of the ore bodies under development is close to the lower camp and at approximately the same elevation. The others lie at elevations between 4,250 and 4,500 feet above sea level on Mount Cameron, about a mile from the lower camp. A pack train is used for the summer transportation of supplies from the bay to the lower camp.

The Mazuma, Treasury Note, and several other claims, seventeen in all, originally located by Cameron & Johnson, were deeded to the Cameron-Johnson Gold Mining Co. A small amount of development work was reported in 1911. The property was leased to Henry Hewitt from March 26, 1912, to February 8, 1913, and considerable development work is said to have been done during this interval, mostly on the Treasury Note claim. A shipment of ore is also said to have been made. Six to eight men were at work there in September, 1912. The next year a mill building, sheathed in corrugated iron and housing a 5-stamp mill and a concentrator, was erected. Power was furnished by a No. 3 Pelton water wheel operating under a 240-foot head with water from a glacial stream carried through 1,500 feet of pipe that decreased in diameter from 11 to 8 inches from the intake to the wheel. Milling began July 20, 1913, and stopped about October 1. An average of 30 men were employed on the property during the working season, but at times as many as 36 were at work. A temporary aerial tram was erected between the mine and the mill during the summer; it was later dismantled. Mining was in progress until the middle of September.

In 1914 mining operations are reported to have begun August 17, and at the close of the season the underground work is said to have aggregated a little over 700 feet. The mill was in operation but a short time. An average of 30 men were employed during the season, which closed about the middle of September. Most of the season was spent in surface improvement of the property. An 1,800-foot temporary aerial tram was erected during the summer, and all the ore mined in 1914 was brought down over it. Later a 3,850-foot aerial tram was completed between the mill and a point on Mount Cameron at an elevation of about 3,700 feet, about 1,300 feet above the mill camp. This replaced the temporary tram. A new dam was also erected. A 7-foot Lane mill and another concentrator were added to the equipment. A bunk house was erected at the mill camp and additions were put on the mill and cookhouse. Two small wooden buildings, a bunk house and a cookhouse, were erected near the upper terminal of the aerial tram.

The country rock in the vicinity of the Cameron-Johnson claims appears to be entirely graywacke and argillite. At the upper terminal of the aerial tram the bedding and schistosity in these rocks has a strike of N. 85° E. and a dip of 80° N.

Of the numerous veins reported as occurring on this property only the lower vein, near the mill camp, has been visited. The data regarding the other veins have been furnished by the present owners.

The vein on the Mazuma claim near the mill is said to be the largest on the property, as well as the lowest in grade. This vein lies on the west bank of Johnson Creek about 40 feet above the mill

camp. A crosscut tunnel 110 feet long is driven N. 20° W. from the bank of the creek and taps the vein at its east end, where it has a strike of N. 65° W. and a dip of 55° N. A 60-foot raise extends to the surface from this point. This vein has been traced along the outcrop about 100 feet and varies in width, the maximum being 11½ feet. The average width in the raise is reported to be about 3 feet. The strike is N. 62°–72° W., and the dip 55°–72° N. The fissure is quartz filled and shows a little secondary banding parallel to the walls.

At the upper workings most of the development work is reported on the Treasury Note vein, which is said to have an easterly strike, to show from 3 to 36 inches of ore, and to be traceable for over 300 feet. The remaining veins are narrower and shorter.

The ore is a free-milling gold quartz ore of which the gangue is dominantly quartz with a minor amount of a brown-weathering carbonate. Gold, pyrite, galena, sphalerite, and arsenopyrite were recognized in specimens of the ore. Limonite forms as a surficial oxidation product of the iron-bearing sulphides. About 3 per cent of the ore is said to be sulphides.

CLAIMS OF SEALEY-DAVIS MINING CO.

The property of the Sealey-Davis Mining Co. is on the east side of Shoup Bay about half a mile north of the Cliff mine and on the opposite side of the ridge. The underground workings are between 200 and 615 feet above sea level. Several wooden buildings, including office, bunk house, cookhouse, and blacksmith shop, are located at tidewater on Shoup Bay. At the lower tunnel a blacksmith shop has been erected, and at the entrance to one of the other tunnels there is a 3-horsepower gasoline engine and blower. Developments in 1914 included four tunnels with about 1,500 feet of drifts and crosscuts, a winze, a short raise, stopes above the upper tunnel, some stripping, and open cuts. One shipment of ore is said to have been made to the Tacoma smelter and another to the custom mill at Valdez.

The country rock of the ore body is a dark-gray fine-grained schistose graywacke with a small amount of argillite. The schistosity has a nearly west strike and a dip of 55° N. The ore deposit occupies a well-defined fissure which strikes N. 23°–35° W. and dips 75° E. to 85° W. The highest definitely located point on the vein is in an open cut at an elevation of 650 feet. The first 50 feet of the lower tunnel, at an elevation of 200 feet, is driven on a narrow iron-stained shear zone; the remainder of this tunnel shows no vein. The other tunnels, at elevations of 425, 560, and 615 feet, are driven on the vein, which varies in width, being in some places

a narrow seam and in others 5½ feet wide. The maximum width of quartz observed was 2 feet. In the upper tunnel the quartz occurs as long, narrow masses from 3 to 15 inches thick, parallel to the walls of the fissure. In the next lower tunnel the quartz in the fissure is fairly continuous and there is from 1 to 15 inches of solid quartz. The maximum thickness of 2 feet of quartz was seen in the next lower tunnel, where the quartz occurs as long, narrow stringers or lenticular iron-stained masses, sheeted parallel to the wall and having a usual width of 1 inch to 15 inches.

The primary ore minerals include quartz, chlorite, calcite, gold, pyrite, arsenopyrite, chalcopyrite, sphalerite, galena, and pyrrhotite. The development of acicular crystals of arsenopyrite in the impregnated graywacke country rock of this vein is not so pronounced as at the Cliff mine. Limonite is present in weathered exposures of the ore body.

ALICE MINE.

The Alice mine is situated at sea level on the west side of Shoup Bay a short distance north of the mouth of McAllister Creek, 1½ miles northwest of the Cliff mine. During 1913 and 1914 a regular boat service was maintained by a gasoline launch between Valdez and the mine.

The vein was located March 15, 1910. In September, 1911, only a small amount of development work had been done. In 1912 an air compressor and pump were installed and a two-compartment shaft sunk to a depth of more than 100 feet below high-tide level. Ten to twelve men were employed, several frame buildings constructed, and 30 tons of ore shipped to Valdez and milled. Development work stopped early in February, 1913, when 15 men were employed on the property.

In 1914 the underground developments comprised an adit 247 feet long, a 170-foot two-compartment timbered shaft crossing the tunnel level 60 feet from the portal of the tunnel, and 100 feet of drifts along the lead at the bottom of the shaft. There was also considerable surface stripping and several shallow shafts (6 to 10 feet deep) along the outcrop of the vein. The buildings included mess house, blacksmith shop, boiler, engine and compressor house, shaft house, and three bunk houses. The plant was electrically lighted and the machinery on the property in 1914 included a 100-horsepower boiler, a 3-drill air compressor, drills, a 50-light dynamo, a 5-horsepower steam engine for the dynamo, a steam hoist, and pumps. Only assessment work is reported on this property in 1914.

The country rock in the vicinity of the ore body comprises schistose graywackes, slates, and a very small amount of green schists. The schistosity has a strike of N. 70°–80° E. and a dip of 50°–70° N.

The Alice claim is located on a well-defined fissure, striking N. 60°–65° W. and dipping 70° S. to vertical, cutting the schistose country rock in both strike and dip. This fissure is traceable as a shallow trough from tidewater to tidewater across a low ridge, a distance of about 1,100 feet, with a maximum elevation of about 120 feet above sea level. The width of the fissure ranges from a few inches to 2½ feet. At one point in the tunnel the fissure filling is about 6 feet wide and shows wide-spaced joints parallel to the walls occupied by long, narrow quartz veinlets. The fissure filling on the tunnel level is usually from half an inch to 8 inches wide but in places is as much as 15 inches wide, most of which is quartz. The ledge matter, consisting of brecciated and sheared country rock, has in some places a width of 6 feet, but the quartz is not abundant in those places.

The gangue minerals are quartz, calcite, chlorite, and a light-colored, brown-weathering carbonate. The metallic ore minerals include gold, pyrite, chalcopyrite, arsenopyrite, and sphalerite. Galena is also reported in the ore. The presence of silver alloyed with the native gold is shown by assays. Limonite is present in the weathered parts of the vein.

THREE IN ONE GROUP.

The Three in One group is situated on the southward-facing slope of the mountain between Gold Creek and Shoup Bay, at an elevation of approximately 1,500 feet. The property is reached by a trail which leaves the shore of Port Valdez at the mouth of a small stream about a mile west of the mouth of Gold Creek.

The underground development work in 1914 consisted of a 500-foot adit, a 160-foot raise, a 50-foot adit at the upper end of the raise, open cuts, and strippings on the vein. The surface improvements include a cabin southeast of the mine at an elevation of about 850 feet and trails to the mine and to the shore from the cabin. Three men were employed on the property in the fall of 1914.

The country rock is schistose graywacke and argillite, the schistosity of which at the mouth of the lower tunnel strikes N. 77° E. and dips 60° N. Only one vein is reported on the property. The lowest outcrop of this vein is at the lower tunnel, at an elevation of about 1,450 feet. The lead is reported to continue up the slope of the hill for about two claim lengths to the crest of the ridge, at an elevation of over 2,500 feet. In the lower tunnel the lead strikes N. 27°–35° W. and dips 50°–80° W. In the upper tunnel it strikes N. 15° W. and dips from 80° W. to vertical. The width of the fissure varies from 3 to 10 feet. The width of the contained quartz is from a few inches to 8 feet, but it averages about 2 feet. The quartz lies in long, narrow lenses. The ore minerals include gold, chalcopyrite, sphalerite, galena, and arsenopyrite. Three kinds of quartz are

reported—a bluish quartz, a massive white quartz, some of which is coarsely crystalline, and a banded quartz.

CLAIMS OF THOMPSON-FORD MINING CO.

The property of the Thompson-Ford Mining Co. is on the east side of Uno Basin about 2 miles from the head of Shoup Bay. The workings are at an elevation of about 2,500 feet above sea level. The claims are reached by a trail from the east side of Shoup Bay about half a mile south of the mouth of Uno Creek.

The present underground workings are on the end line between the Silver Falls and Foaming Falls claims. Nearly continuous development of the property is reported by the owners up to 1914. In 1913 four men were employed during the first half of the year and one man during the remainder of the season. A shipment of ore was also made to the Tacoma smelter during the summer. Two men were at work on the property in the fall of 1914.

The underground developments include a lower tunnel 325 feet long, with two drifts 100 and 25 feet in length; a 150-foot raise from the lower tunnel to the surface; a 20-foot shaft and a 15-foot drift from the bottom of this shaft to the raise; and about 100 feet of drifts on a level 60 feet below the collar of the raise.

The country rock of the Thompson-Ford ore body consists of sheared graywackes and argillites. The strike of the schistosity of these beds is N. 75°–80° E. and the dip 65°–75° N. The strike of the vein on the surface is from N. 50°–60° W. and the dip 50°–85° N. At the shaft the vein has split and includes a 10-foot horse of sheared country rock. This vein ranges in width from 1 inch to 18 inches, but has an average width of about 8 inches, and the surface showing is 115 feet long. The walls of the vein are free. On the 60-foot level a vein 6 to 12 inches wide strikes N. 35°–45° W. and dips 85° SW. It is exposed for about 15 feet. Numerous small quartz stringers also occur in the workings on this level. On the lower level a poorly delimited sheared zone with a general northwesterly strike is cut diagonally by a long tunnel. Within this zone the schistose rocks are much contorted and crumpled and in places contain numerous quartz stringers, some of which are several inches thick. The first 20 feet of the crosscut at the end of the long tunnel lies in this zone, which is also exposed in this tunnel for over 50 feet from the crosscut. A shear zone 8 to 15 inches wide with a strike of N. 75° W. is reported at the end of this crosscut. The gangue minerals, as in most of the other ores of this district, consist chiefly of quartz, with a little calcite. Pyrite is the most abundant sulphide, but galena, sphalerite, and chalcopyrite are also present. The ore is a free-milling gold ore, the gold occurring native. Limonite is present in the weathered ore.

CLAIMS OF SEACOAST MINING CO.

The claims of the Seacoast Mining Co. are on the southwestward-facing slope of Mount Shasta about a mile northeast of the mouth of Uno Creek. Several veins are reported to occur on the property at elevations from 1,750 to 2,600 feet above sea level. The mine workings are reached by a trail from the lower camp at the mouth of Uno Creek.

The total underground development work in 1914 comprised a 265-foot crosscut tunnel with a 4-foot winze and a 10-foot raise, a 50-foot crosscut tunnel, a shallow shaft, open cuts, and stripping. The surface improvements consisted of an upper camp (one wooden building) at an elevation of 1,800 feet, a small wooden building part way up the trail, four buildings at the mouth of Uno Creek, and the trail from the shore to the upper camp. An average of 15 men are reported to have been employed on the property in the summer of 1913. In 1914 two men were employed during the early part of the summer and seven men were at work in September. A small shipment of ore has been made to Seattle for a sample mill test.

The country rock of the veins is the schistose graywacke and argillite prevalent in the Shoup Bay area. The strike of the schistosity is N. 60°–80° E. and the dip is 60° N.

Several veins are reported on the claims owned by this company. At the upper camp a vein that is traceable for about 150 feet strikes N. 25° W. and dips eastward. Irregular lenses of quartz occur in the fissure, and above the long tunnel a width of 28 inches of solid quartz shows in the vein. Just east of the tunnel a spur vein 12 inches wide leaves the main vein on the uphill side and has a strike of N. 55° E. and a dip of 55° N. Within the tunnel a large mass of quartz was cut 30 feet from the portal and a winze was started on it. In the winze this lens had a maximum width of 10 feet, but the vein narrowed upward to a few inches. The hanging wall of this vein in the east wall of the tunnel is well defined and strikes N. 10° W. and dips 55° E. The continuation of this vein in the northwest wall of the tunnel has a width of 2 feet. At 25 feet beyond the winze a vein 3 to 24 inches in width crosses the tunnel with a strike of N. 33° W. and a dip of 47° W. At an elevation of 1,850 feet an inclined shaft is being sunk on a vein reported to be traceable for 250 feet. This fissure varies in width from a fraction of an inch to 11 feet. The maximum width of solid quartz exposed is 2 feet. The strike of the vein ranges from S. 80° E. to N. 10° E. and the dip from 40° to 60° N. A lead on the Portland claim is said to range from 6 inches to 6 feet in width and to be traceable for several hundred feet.

The minerals present in the ores of the Seacoast Mining Co.'s veins include quartz, chlorite, calcite, a brown-weathering carbonate, pyrite, galena, gold, pyrrhotite, chalcopyrite, and sphalerite. Large masses of pyrite occur in the vein opened by the inclined shaft. Oxidation products present are limonite and malachite.

SILVER GEM CLAIM.

The Silver Gem claim is at tidewater on the southwest side of Shoup Bay about a quarter of a mile from the front of Shoup Glacier and half a mile northwest of the Alice mine. The underground developments consist of an adit about 500 feet in length, 10 feet above sea level. It is reported that a shipment of ore from this claim was made to the custom mill at Valdez and milled there.

The country rock of the ore deposit is a schistose gray graywacke, in places impregnated with pyrite. The schistosity strikes N. 68°–88° E. and dips 62°–66° N.

The Silver Gem claim is staked on the north end of a well-defined fissure[1] traceable about half a mile southwestward from tidewater at the tunnel mouth. This fissure forms a pronounced trough on the hillside and across the ridge. At the tunnel mouth it strikes N. 10° W. and dips 70°–80° W. Within the tunnel the fissure curves, and near the face of the tunnel the strike is N. 35° E. and the dip 55° W. The width of the fissure filling is from 6 inches to 9 feet, but the average width is about 2½ feet. The hanging wall is well defined and slickensided. The fissure filling consists of crushed and shattered country rock with varying amounts of quartz. Many small stringers and lenses of quartz occur in the vein filling. The largest mass of quartz observed was a short lens 28 inches thick. In places the shattered graywacke of the vein material is cemented by mineralized quartz. Most of the quartz is badly shattered.

Quartz, calcite, and chlorite are the gangue minerals. Pyrite, arsenopyrite, sphalerite, and stibnite have been observed in the ore, and galena and free gold are reported. There is also a pyritic impregnation of the schistose graywackes adjoining the vein. Limonite is present in the weathered outcrops.

BALD MOUNTAIN GROUP.

The Bald Mountain group, better known locally as the Olson property, is on the right margin of Shoup Glacier at an elevation of about 3,100 feet above sea level. It is about three-fourths of a mile northeast of the Cameron-Johnson mill camp and about 650 feet higher.

[1] Brooks, A. H., Gold deposits near Valdez: U. S. Geol. Survey Bull. 520, p. 123, 1912.

It is reached from Shoup Bay, 7¼ miles distant, by way of the Cameron-Johnson trail.

The surface improvements on the property comprise stripping and open cuts on the veins and a small wooden cabin. The underground developments consist of two tunnels 180 and 36 feet in length, at elevations of 3,050 and 3,250 feet respectively, and a shallow shaft on one of the veins. The longer tunnel comprises a 120-foot crosscut and 60 feet of drift, 50 feet of which was opened in 1914. The country rock of the veins is schistose graywacke and argillite, the schistosity and bedding of which strike N. 60°–80° E. and dip 70°–77° N.

Development work has been done on two veins, each of which is reported traceable for several hundred feet. The upper vein has a strike of N. 75° W. and a dip of 65° N. Its width varies from 4 to 18 inches. The other and larger lead has a maximum width of 7 feet and about the same strike as the upper vein. Other leads occur on the property but have not yet been prospected. One of them is 4 to 5 inches wide and is traceable for over 100 feet. The gangue of the ore is chiefly quartz with a small amount of light-colored, brown-weathering carbonate. The sulphide minerals observed in specimens of ore from this property are pyrite, sphalerite, and galena.

MINNIE CLAIM.

The Minnie claim is on the right margin of Shoup Glacier at an elevation of about 3,000 feet, a short distance northeast of the Bald Mountain group. The claim was located in July, 1911. The developments in 1913 included a 35-foot tunnel, a 20-foot tunnel, one or two shorter tunnels, some surface stripping of the veins, and a small wooden cabin. Several attempts to ship ore to custom mills were stopped by accidents, and in 1913 a 1-stamp mill operated by water power was placed on the claim and run for about 25 days in the fall by two men.

Several small veins are reported to occur on this property. The vein on which the two longer tunnels are driven and which supplied the ore for the mill has been stripped for about 150 feet. The fissure strikes N. 70° W. and dips 55° S. The country rock is the usual graywacke and argillite, the bedding and schistosity of which strike N. 84° E. and dip 75° N. This lead contains from 4 to 24 inches of quartz, but the average width is only 9 inches. The ore minerals are quartz, pyrite, galena, and gold.

OWL PROSPECT.

The Owl prospect is in Uno Basin, about half a mile southwest of the Thompson-Ford workings, at an elevation of about 2,400 feet. It is about 1½ miles from Shoup Bay and is reached by the same trail as

the Thompson-Ford claims. This prospect, formerly the property of the Owl Mining Co., was restaked January 6, 1914, by George Pulver and E. J. Baker as the Oregon and Washington claims. The underground developments total about 190 feet. The country rock is graywacke and argillite, the schistosity of which strikes N. 85° E. and dips 55° N. The ore deposit consists of a sheeted or sheared zone several feet wide which carries several large stringers and lenses of quartz that have a maximum thickness of 18 inches. The quartz outcrops are traceable for a distance of about 150 feet along the strike, which is approximately N. 45° W. The dip is 30° E. The tunnel is driven along the fissuring. The gangue minerals are quartz, calcite, and chlorite. Pyrite, chalcopyrite, galena, and sphalerite are the sulphides present. Limonite and a little malachite occur in the weathered outcrops of the ore body.

GUTHRIE & BELLOLI PROPERTY.

The Guthrie & Belloli tunnel lies at the entrance to Uno Basin, at an elevation of 1,300 feet. It is just north of the trail to the Thompson-Ford and Owl prospects and three-fourths of a mile from the east shore of Shoup Bay. The tunnel is about 150 feet in length. The country rock is sheared graywacke and argillite, the schistosity of which strikes N. 87° E. and dips 63° N. The vein on the surface strikes about N. 25° W. and dips 60° E. The outcrop is traceable for about 100 feet, and the width ranges from 1 foot to 10 feet. Within the tunnel the vein strikes N. 58°–73° W. and shows a maximum width of 6 feet of quartz. The gangue minerals are quartz, calcite, and chlorite. The metallic ore minerals include pyrite, chalcopyrite, arsenopyrite, sphalerite, and galena. Limonite is present as a surficial oxidation product of the iron-bearing sulphides.

BUNKER HILL CLAIM.

The Bunker Hill claim is on the southwest slope of Mount Shasta, three-fourths of a mile northeast of the head of Shoup Bay, at an elevation of 1,800 feet. It is reached by a trail from the mouth of Uno Creek. The underground development in 1914 consisted of a 100-foot adit. The country rock is the usual schistose graywacke.

The vein on which the tunnel is driven ranges in strike from north to N. 70° E. and dips 63° W. The quartz filling of the fissure is somewhat lenticular and ranges in thickness from 4 to 25 inches. A small fold, the axis of which pitches 70° NE., exposed in the tunnel about 35 feet from the portal, is occupied by the vein. In some places the quartz is shattered; in others the vein shows secondary banding parallel to the walls of the fissure, which are free and in places marked by gouge. The ore minerals are quartz, calcite, chlorite, arsenopyrite, galena, pyrite, sphalerite, and limonite.

GOLD BLUFF CLAIM.

The Gold Bluff claim is at sea level on the east side of the entrance to Shoup Bay. It is on the northwestward-facing slope of the same ridge as the Cliff mine and the Sealey-Davis properties, but about half a mile northwest of the Cliff and half a mile southwest of the Sealey-Davis.

The present developments consist of a 200-foot adit, a 5-foot crosscut, and a small building at the tunnel mouth. The country rock is schistose graywacke, the schistosity of which strikes N. 85° E. and dips 52° N. The tunnel is driven along a shear zone which very nearly parallels the schistosity of the country rock. The shear zone strikes N. 80° E. to S. 88° E. and dips 55°–63° N. at different places in the tunnel. The width of the shear zone is from 2½ to 4 feet. It contains a few short lenses of white quartz with a maximum thickness of 4 inches. In places no quartz was visible in the tunnel. At the face of the tunnel narrow stringers of quartz with a maximum thickness of half an inch show in the shear zone, which is here 3 feet wide. The minerals recognized in hand specimens of ore collected on the property in 1914 are quartz, calcite, chlorite, pyrite, pyrrhotite, and chalcopyrite.

BLUEBIRD GROUP.

The Bluebird group is on the southeastward-facing slope of the mountain west of the entrance to Shoup Bay, at an elevation of about 650 feet. The improvements on the property include a crosscut tunnel 100 feet in length, with a 10-foot drift at the face of the tunnel, a 10-foot tunnel near the west end of the vein, open cuts on the vein, a trail from the shore to the prospect, and three buildings on the beach.

The country rock is a schistose graywacke, the schistosity of which has an easterly strike and a dip of 40°–60° N. The long tunnel is driven about 30 feet below the outcrop of the lead, which is traceable southwestward along the hillside for about 200 feet and appears to have about the same strike and dip as the schistosity of the country rock. The wall followed in the drift at the end of this tunnel strikes N. 75° E. and has a vertical dip. The ore body on the surface consists of a poorly defined mineralized shear zone 4 to 10 feet in width. The fissure filling is made up largely of lenticular masses of a much-shattered mineralized fine-grained to dense, heavy dark greenish-black basic dike rock. The shattered portions are in many places cemented by an irregular network of mineralized quartz. The shear is indistinct in the tunnel, although at the face bunches and irregular masses of quartz occur in the shattered country rock. The ore minerals are quartz, calcite, chlorite, pyrrhotite, chalcopyrite, galena, and pyrite.

OTHER PROSPECTS.

There are several other prospects in the Shoup Glacier valley and vicinity, which have not yet been studied but upon which considerable development work has been reported. On the property of the Rambler Gold Mining Co. a 230-foot tunnel and two shafts, 18 and 20 feet deep, were reported in 1913. A 130-foot adit has also been driven on the Bence-McDonald ground, and short tunnels are reported on the Ivanhoe property, near the head of Shoup Glacier; on some claims near the Minnie claim, on the right margin of Shoup Glacier; and on a claim near those of the Seacoast Mining Co., belonging to Henry Stevens.

Along the north shore of Port Valdez between the Cliff mine and Gold Creek several hundred feet of tunnels are reported on the Ellis Imperial, Black Diamond, and other properties, none of which have yet been visited.

COLUMBIA GLACIER PROPERTIES.

GOLD KING MINE.

The Gold King mine is at an elevation of 3,750 feet on the east end of an ice-surrounded mountain rising out of Columbia Glacier. It is about 6¼ miles in an air line from Shoup Bay and 18 miles from the foot of Columbia Glacier. It is reached by a trail about 8 miles in length which leaves tidewater at the head of Shoup Bay, traverses Shoup Glacier to the Midway camp, at an elevation of 1,300 feet, and then crosses the high mountain range between Shoup and Columbia glaciers through a pass about 4,400 feet in elevation.

The Gold King ore body was located July 26, 1911, by Olaf Olsen, Frank Gustafson, and Hans Andersen, and several hundred pounds of high-grade ore was brought to Valdez in that and the following year. In October, 1912, after the locators had tapped the vein in a crosscut tunnel at the upper workings, the property was taken over by the Gold King Mining Co., which started development work on its own account in December, 1912. During the winter of 1912–13 machinery and supplies were taken in over Shoup Glacier, with the aid of gasoline hoists. In September, 1913, the surface improvements included a mill building, housing a crusher, feeder, 3½-foot Huntington mill, amalgamating plates, and a concentrator, all operated by gasoline engines, besides several camp buildings. The camp was built on the terminal moraine of a small hillside glacier. The mill was at a slightly lower elevation. This company also owned the Midway camp, on Shoup Glacier, and two small wooden buildings on Shoup Bay. A telephone line connected the mine with Shoup Bay. A pack train and a dog team were used for the transportation

of supplies during the summer of 1913. In the winter of 1913–14 the bunk house was carried away by a snowslide.

Milling operations began August 13, 1913, and the mill ran for about 40 days that season. In 1914 the mill was started June 16 and ran until August 27.

The underground development work in September, 1913, when the property was visited,[1] consisted of No. 1 tunnel, with several hundred feet of drifts and crosscuts, a 60-foot winze, and 90 feet of drifts from the bottom of the winze; No. 2 crosscut tunnel, about 400 feet long, with 15 feet of drifts on a small fissure crosscut 260 feet from the portal; No. 3 crosscut tunnel, 60 feet long, with 40 feet of drifts; and some open cuts and stripping. The underground development in 1914 is said to have consisted in drifting west on a crosscut on the lower level and in stoping in the east vein and in the No. 1 vein. The long crosscut tunnel was also continued to a length of 669 feet, but the vein had not been encountered. Development work was in progress from early in March until September, and from 16 to 22 men were employed.

The country rock is chiefly graywacke but contains some zones of banded argillite, one of which has a width of about 50 feet. The bedding strikes N. 65°–72° E. and dips 62° N. to 90°. A granite outcrop, about 50 by 100 feet, intrusive into the graywackes and argillites and cut by mineralized quartz veins and stringers, is reported in the west end of Gold King Mountain.

Two veins are being developed on the Gold King claims—the upper or saddle vein (No. 1), on which most of the work has been done, and the lower vein (No. 3), east of the camp buildings. The saddle vein strikes N. 60° W. and dips 50°–60° S. Its width ranges from 2 to 18 inches, but the average width is probably under 1 foot. At one point the quartz occurs as narrow stringers in a belt of shattered mineralized graywacke 5 feet wide. The vein in many places shows secondary banding parallel to the walls. On the surface the vein has a good footwall but a less well defined hanging wall. Underground the footwall of the vein is well defined, the quartz usually breaking free but showing no gouge. On the hanging wall about an inch of gouge is present. This vein is cut by a fault which strikes N. 74° E. The filling of the fault fissure is from 2 to 18 inches thick and contains a little quartz. On the west side of this fault, about 120 feet southwest of No. 1 vein, a small vein 1 to 6 inches wide, striking nearly parallel to the fault, has been found.

No. 3 vein is tapped by a crosscut tunnel 60 feet long and is followed by drifts in both directions. This vein strikes N. 70°–77° W.

[1] Johnson, B. L., Mining on Prince William Sound: U. S. Geol. Survey Bull. 592, pp. 237–238, 1914.

and dips 65°–70° N. It shows a width of 8 to 36 inches of solid quartz, and in one place a width of 5 feet is reported. The vein shows considerable secondary banding parallel to the walls of the fissure, the hanging wall of which breaks free. The hanging wall carries from 4 to 8 inches of gouge, and in places the gouge is visible on both walls.

In the long crosscut tunnel (No. 2) a fissure striking N. 85° E. and dipping 70° N. was cut 260 feet from the portal. The fissure has well-defined walls and the fissure filling ranges from 15 to 30 inches in width. Quartz occurs as small stringers in the soft iron-stained fissure filling.

The ore is free milling. Quartz is the dominant gangue mineral, although calcite and a cream-colored, brown-weathering carbonate are also present. The metallic minerals in the ore are gold, pyrite, galena, sphalerite, chalcopyrite, and stibnite. The ore contains about 3 per cent of sulphides. Pyrite cubes impregnate the graywacke adjacent to the veins. Limonite and the red and yellow alteration products of stibnite are found in the weathered outcrops of the veins.

CLAIMS OF MAYFIELD GOLD MINING CO.

The claims of the Mayfield Gold Mining Co. are on the steep southward-facing slope of a mountain jutting westward into Columbia Glacier in the extreme western part of the Port Valdez district, about 7½ miles from tidewater on Shoup Bay. The ore body lies at an elevation of nearly 3,000 feet above sea level and is reached from Shoup Bay by a trail through the Anderson Glacier pass. Assessment work only has been done on these claims since July, 1912. The underground developments in August, 1914, consisted of two tunnels—an upper crosscut tunnel 105 feet in length and a lower tunnel with nearly 350 feet of drifts and crosscuts.

The country rock of the ore deposit consists of closely folded graywackes and argillites, the bedding and schistosity of which strike N. 70°–80° E. and dip 50°–60° N. West of the lower tunnel parallel jointing, striking N. 20°–30° W. and having a vertical dip, is rather conspicuous.

About 50 feet above the upper tunnel a poorly defined fissure is traceable S. 70° E. along the hillside for a distance of several hundred feet, cutting the schistosity of the interbedded graywackes and argillites at a slight angle. At intervals along this fissure there are stringers, bunches, and lenses of quartz in the fissure filling. This break is also traceable for a considerable distance west of the ore body now developed. Practically no quartz is visible in this portion of the outcrop of the fissure, however, but the adjacent country rock is markedly iron-stained. The ore body under development lies at

the intersection of the fissure above mentioned with a spur break, striking N. 20°–30° W. and dipping 50° E. The spur lead has been stripped for about 50 feet from the mouth of the upper tunnel to its junction with the other fissure, which it does not appear to cross. Above the upper tunnel the main fissure contains about 10 feet of ledge matter, a large part of which is quartz. From this point considerable quartz shows in this fissure for a distance of about 200 feet westward to a point just beyond the junction of the main and spur leads. At the junction of the two leads a maximum width of 8 feet of solid quartz is visible. The spur lead shows on the outcrop from 1 to 6 feet of quartz. The fissure cut at the face of the upper tunnel has a strike of N. 30° W. and a dip of 45° E. In the lower tunnel, which is about 100 feet below the outcrop of the main vein, a fissure was cut 200 feet from the portal of the tunnel. A drift was driven 90 feet westward along this fissure, which has a strike of S. 70° E. and a dip of 60° N. where crosscut. It ranges from 1 foot to 5 feet in width. The fissure filling is composed of sheared and shattered graywackes and argillites with a comparatively small amount of quartz. At the end of the drift on this fissure a large quartz vein, probably the spur lead, was encountered. A 30-foot drift has been driven along this vein, which has a strike of N. 30° W., the same as that of the spur lead on the surface.

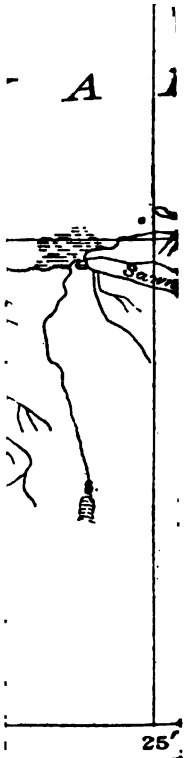
Quartz was the only nonmetallic gangue mineral observed in the Mayfield ore. The metallic minerals include gold, pyrite, chalcopyrite, galena, sphalerite, and arsenopyrite. Limonite and the greenish oxidation products of arsenopyrite are visible on the weathered outcrop of the veins.

OTHER PROSPECTS.

A small amount of development, chiefly the result of assessment work, has been done on a few other prospects near Columbia Glacier, which have not yet been visited by Geological Survey parties. One of these properties, originally located as the Bessie Williams, was restaked in 1914, and preparations for its development were being made during the summer by the Mammoth Mining Co.

GOLD PLACERS.

Placer operations have never created a great deal of interest in the Port Valdez district. The gravel areas are small, and much of the gravel has a low gold content. In 1914 a small amount of placer gold was obtained from the upper reaches of Lowe River and from sluicing operations on the upper end of Mineral Creek. Some of the gravel flats on Mineral Creek were tested also by drilling.



S AND PRO

On Gold Creek the Budd Mining Co. continued preparations to work gold placers in the basin above the lower falls. Commencing April 22 six men were employed in clearing the trail and freighting supplies and construction materials from the beach to the Gold Creek basin. The force was increased in two weeks to eight men, and that number was employed until June 16, when the work was stopped for the season owing to a proposed change of ownership. During this time a false dam was built for the diversion of water to permit the laying of bed pieces for the true dam. At the time of stopping the mudsills for the true dam had been laid in concrete on bedrock. About 200 feet of 3 by 6 foot flume had also been built, which will give a head of 120 to 150 feet for hydraulicking.

SOLOMON GULCH.

MIDAS MINE.

The Midas copper mine, now the property of the Granby Consolidated Mining, Smelting & Power Co. (Ltd.), of Canada, is situated at an elevation of about 800 feet above sea level, at the base of the mountain ridge bordering the west side of Solomon Gulch, about 4½ miles from Port Valdez.

The surface developments on the property in the fall of 1914 comprised a wagon road from the shore to the mine; an aerial tram, 4½ miles long, nearly completed from the bay to the mine workings; wharf and ore bunkers at the coast terminal of the aerial tram; several buildings on shore near the wharf; ore bunkers, bunk house, three cottages, and foundations for two more, at the mine. The principal underground developments consist of two adits, each several hundred feet in length, with a vertical interval between them of 92 feet, and three raises, two of which connect these two levels. The total underground developments are reported to include over 1,600 feet of tunnels, drifts, and raises. About 150 feet of this work is said to have been done during July and August, 1914. There are also some shallow shafts and strippings on the outcrop of an ore body upstream from the mine camp. The number of men employed on the property varied from 15 to 75 during the year. The property was closed August 31, 1914, after the outbreak of the European war.

The country rock of the ore deposits is composed of black slates, argillites, graywackes, cherts, light-gray and greenish schists, and greenstones, with some associated light-colored aphanitic silicic intrusive rocks. Most of the rocks exposed in the immediate vicinity of the mine are sedimentary. A large mass of greenstone, coarsely crystalline in some places and sheared in others, crops out near the head of the valley. Heavy-bedded graywackes occur above the mine.

The present developments show two apparently distinct ore bodies, one on the west side of the valley, where the present extensive developments are being made, and the other about half a mile upstream from this locality, in the middle of the valley bottom. Both deposits occur in mineralized shear zones. The lead now under development has been traced for several hundred feet into the hill by the tunnels. On the surface the highest showing of ore is about 650 feet above the lower long tunnel. The strike of the shear zone lies between N. 75° W. and S. 62° W. and the dip is 40°–70° N. The width ranges from 1 foot to 14 feet but the average width of ore is between 3 and 4 feet. The other ore deposit appears as a sulphide-impregnated, closely folded, shattered, and sheared series of sedimentary rocks; the mineralized zone is wider and the ore in this zone is said to be of lower grade than in the developed ore body at the mine camp. The bedding and schistosity at this deposit strike N. 57° W. and dip 60° N.

The ores are partly replacements of the crushed country rocks and partly the result of cementation of small fractures by the ore minerals. The sulphide minerals present are pyrite, chalcopyrite, and pyrrhotite. It was thought that sphalerite was detected in some of the specimens, but it was too fine grained for macroscopic determination. Numerous tests for zinc with negative results are reported by local assayers, so that it is believed that sphalerite is scarce or lacking in this ore. A little quartz is associated with the sulphides. Some limonite has resulted from the surficial oxidation of the iron-bearing sulphides, and malachite stains from the carbonation of copper minerals. Gold and silver are reported in assays of the ores, but neither metal has been observed in specimens. With the exception of galena and arsenopyrite, which have not been observed in the specimens examined, the association of metallic minerals is the same as that of the other copper deposits and the gold quartz deposits of the Prince William Sound region.

MINERAL RESOURCES OF THE CHISANA-WHITE RIVER DISTRICT.

By STEPHEN R. CAPPS.

INTRODUCTION.

The district covered by this paper lies on the northeast side of the Wrangell and St. Elias mountains and includes parts of the upper basins of White and Chisana rivers. (See fig. 5.) The area is irregular in outline but lies between parallels 61° 30′ and 62° 20′ north latitude and meridians 141° and 142° 20′ west longitude. It includes

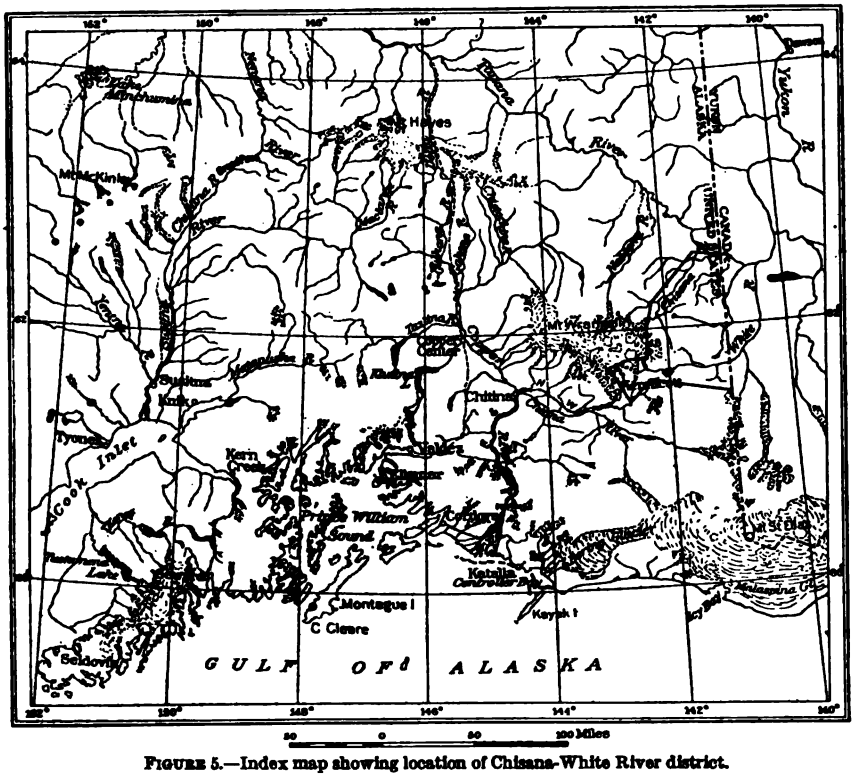


FIGURE 5.—Index map showing location of Chisana-White River district.

the northern front of the St. Elias and Wrangell mountains, the south slope of the Nutzotin Mountains between the international boundary and Chisana River, and the broad basins and less rugged hills between them. Figure 5 is an index map, showing this general region.

After the discovery of gold in the Klondike and the stampede to that field in 1897 and 1898, a number of prospectors worked southward into this general region, and in 1902 a reported discovery of placer gold in the basin of Beaver Creek brought on a small gold rush to the White River basin, but no workable placer gravels were then found and most of the gold seekers soon left. A few who stayed were led to the search for copper deposits, for Indian reports of rich occurrences of native copper in the White River valley had long been known. A number of copper-bearing localities were found, and the development of these and prospecting for other lodes have continued to occupy the attention of a few men ever since. The region, however, is difficult of access and had been visited by comparatively few white men up to the spring of 1913. The discovery of placer gold in 1913 and the widely circulated reports of the richness of the district led to a great influx of gold seekers in the fall and winter of that year and created a demand for more recent information about the district than was available. Accordingly two parties were organized to map the country both topographically and geologically. The topographic party in charge of C. E. Giffin, commenced work on Nizina River near the mouth of the Chitistone, resurveying the upper Nizina basin and the head of the White River basin and extending the mapping northward to the north front of the Nutzotin Mountains east of Chisana River. The geologic mapping was carried over much the same territory, but the north slope of the Nutzotin Mountains was not visited by the geologist. The topographic and geologic mapping was intended to supplement and extend the work which had already been done in portions of this area.

Geologic investigations of parts of this district have been made by a number of men in previous years. C. W. Hayes made the first geologic observations in 1891, and Alfred H. Brooks examined portions of the area in 1899. F. C. Schrader in 1902 and F. H. Moffit, Adolph Knopf, and S. R. Capps in 1908 again visited parts of this field, and D. D. Cairnes, of the Canadian Geological Survey, briefly examined the gold placer district in 1913. Fuller reference to the work of these writers and to their published reports will be given in a more complete report on this district, now in preparation, but the facts now known with regard to the geology and mineral resources of the district are the result of the work of these earlier investigations as well as of the expedition upon which this report is based, and their published reports have been drawn upon freely by the writer. The report by Moffit and Knopf [1] is the most complete description of the district that has so far been published.

[1] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska, with a section on the Quaternary by S. R. Capps: U. S. Geol. Survey Bull. 417, 1910.

The conclusions reached in this paper and the accompanying sketch map showing the geology of the Chisana mining camp (Pl. IX, p. 202) are the result of only a preliminary study of the material at hand and are subject to revision in the more complete report.

There is a regrettable confusion in the use of names for a number of the important streams in this district. Chisana River, the name used on Witherspoon's map of 1902, was approved by the United States Geographic Board and has so appeared on all official maps since. Many prospectors in that vicinity have, however, persisted in pronouncing the name as if it were spelled Shushana, and that spelling was for a time rather widely used by the newspapers in reporting the discovery of placer gold in 1913 and appeared on some sketch maps of the region. In a similar manner the prospectors ignored the authorized names of other streams in that vicinity and rechristened Chathenda Creek as Johnson Creek and Chavolda Creek as Wilson Creek. These names are still current among the miners, but in this report the approved names for these streams are used.

GENERAL DESCRIPTION OF THE DISTRICT.

GEOGRAPHIC FEATURES.

The Chisana-White River district is one of unusual scenic beauty. It is bordered on the south by the high and rugged Wrangell and St. Elias ranges, their summits capped by perpetual snows and each of the larger valleys holding a great glacier. The abrupt northern face of the St. Elias Mountains, on the south side of White River, culminates near the international boundary in Mount Natazhat, a double-peaked mountain 13,486 feet in elevation. The range has other higher peaks to the south, but none appear so conspicuous from the area here described. The Wrangell Mountains contain a number of peaks higher than Mount Natazhat, but from the district between White and Chisana rivers no single mountain appears greatly to overtop its neighbors, and the impression given is of a vast number of mountains of the same general height, all covered by snow and flanked by fields of glacial ice.

Between the Wrangell and St. Elias ranges on the southwest and the Nutzotin Mountains on the northeast there is a broad area of smoother hills and less rugged mountains. Here the alpine belt merges into a treeless area of broad, tundra-covered valleys and smooth, rounded hills of lesser elevation. The hills rise to elevations not generally exceeding 7,000 feet above sea level, and the broad valleys which cut them are between 4,000 and 5,000 feet high, so that the relief is much less than in the mountain ranges to the north and south. The area also contains no sharp, serrate ridges nor glaciers.

The northeastern portion of this area falls within the Nutzotin Mountains. This range is of alpine character and consists of a belt of sharp peaks and ragged ridges, separated by steep-walled mountain valleys. The highest peak is Mount Allen, which has an elevation of 9,489 feet, and many points reach heights of 7,000 to 9,000 feet. Some glaciers are present in the more favorably situated valley heads, and many mountains rise above the level of perpetual snow; but the glaciers are comparatively small and, unlike those of the Wrangell and St. Elias mountains, are not conspicuous features of the landscape.

Two large rivers receive the drainage from this district. Chisana River has its source in a great glacier of the same name and drains a portion of the Wrangell Mountain mass, part of the Nutzotin Mountains, and a part of the area between these ranges. White River heads in Russell Glacier and is fed by a number of glacial streams which rise in the ice fields of the Wrangell and St. Elias ranges. Beaver Creek, a tributary of the White, drains the south flank of the Nutzotin Mountains east of the Chisana basin. It receives only a small part of its waters from melting glaciers and is a clear stream except in times of flood. Chisana and White rivers, however, are largely fed by streams of glacial origin and are characteristic of streams of this type. They are heavily charged with sand, gravel, and silt, are turbid throughout the summer season, and flow over broad gravel and sand flats built up of the surplus load supplied by the glaciers. They are subject to rapid fluctuations in volume, the flow being influenced by the daily range of temperature in the tributary ice fields, as well as by seasonal changes and by local conditions of rainfall.

GLACIATION.

Although valley glaciers of large size are numerous in the Wrangell and St. Elias mountains, and many smaller ice tongues are to be found also in the higher portions of the Nutzotin Mountains, these glaciers are but the remnants of much greater ice fields which formerly occupied this region. At the time of their greatest development the glaciers completely covered all of the region except the higher mountain ridges. One vast glacial field extended from the White River valley to the Nutzotin Mountains, broken only by a few projecting mountains. The slowly moving glaciers had great erosive power and profoundly altered the shape of the land which they covered, smoothing off and rounding the hills and widening and deepening the valleys. They also disturbed the preglacial drainage to so great an extent that old stream courses were completely abandoned and new valleys formed. The results of the erosion of glaciers and of their disturbing effect upon the drainage are particularly significant in the district in which placer gold occurs,

and the present distribution of the gold can be properly accounted for only after the influence of the glacial ice is taken into account. A fuller discussion of the influence of the ice upon the distribution of placer gold will be given in the more complete report on this district.

ROUTES OF TRAVEL.

The Chisana district is remote from all the well-established systems of transportation in Alaska (see fig. 5), and the available routes to it offer certain difficulties, so that communication with it is slow and the transportation of supplies is tedious and expensive. During the winter of 1913–14 the cost of transporting supplies by sled varied greatly with different freighters, being controlled by the efficiency with which the work was done, by the route traveled, and by the quantity of material moved. Reported costs of sledding, not including railroad or steamer freights to the point from which sledding began, varied from 12 to 50 cents or more a pound, but most of the contracts for freighting were let at prices between 20 and 30 cents a pound.

Seven different routes of travel to this district are available, and each has been traveled by many people. The route chosen by any person is naturally determined by the direction from which he wishes to approach the district, but for one coming to Alaska from Seattle a number of routes are available. Various articles have been published which make much of the difficulties of approaching this district, and especially of the dangers encountered in traveling the trails that lead from McCarthy by way of Nizina and Chisana glaciers and over Russell Glacier. It is true that during the stampede several persons were drowned in rashly attempting to ford the glacial Chitistone and Nizina rivers or their tributaries during periods of high water, but so far as could be learned only one man of several thousand who crossed the glaciers was lost. None of the routes is easy, and none should be attempted without proper equipment, but one familiar with the conditions of travel by trail in Alaska may use any of the routes here described. (See fig. 5, p. 189.)

NIZINA–CHISANA ROUTE.

The shortest route from the coast and the one most used during the winter of 1913–14 was by way of the Copper River & Northwestern Railway from Cordova to McCarthy, a distance by rail of 191 miles. From McCarthy all travel goes up the Nizina Valley to the mouth of Chitistone River, where the trail forks. For winter travel a trail was established up the Nizina to Nizina Glacier and thence up that glacier to its head, across a high ice divide with an elevation of about 8,000 feet, down Chisana Glacier to its terminus, and down Chisana Valley to the town of Chisana, a total distance of about 75

miles from McCarthy, of which about 40 miles is on glacial ice. This route was much used both by foot travelers and for freighting during the winter of 1913–14 and has the advantage of being at a shorter distance from a railroad than any other route. It is, nevertheless, a difficult and dangerous trail and was made passable only by the building of many temporary bridges across crevasses in the glaciers and by a careful staking of the trail so that crevasses could be avoided when the snows had covered and concealed them. The movement of the glaciers also frequently caused the crevasses to engulf the bridges and opened new cracks which in turn required bridges. Furthermore, almost all work on the glacier portion of this trail must be renewed each fall, and new trails must be staked at places where changes in the ice conditions have rendered the old trail impassable. It seems probable, therefore, in view of the impossibility of establishing a permanent trail over the glaciers and the cost of restaking a trail and building new bridges each winter, that the route over Nizina and Chisana glaciers will not be long used.

NIZINA–WHITE RIVER ROUTE.

For summer travel a different route, by way of White River, was generally followed. From the mouth of Chitistone River two branches are available. One takes the same course as the glacier route up to and for a few miles on Nizina Glacier but branches eastward, crossing that glacier to the mouth of Skolai Creek. The Skolai Valley is then followed for 15 miles to its head in Russell Glacier. The other branch ascends Chitistone River to its head and crosses a high pass to the head of Skolai Creek, where the two branches join. Each of these branches presents some advantages over the other, and the travelers are about equally divided in their preferences. The Nizina-Skolai branch is several miles longer and necessitates the fording of Nizina River and the crossing of Nizina Glacier, but the trail is fairly good, the grade is moderate, and there is a better distribution of grass for horse feed. The Chitistone branch crosses Chitistone River several times, and that stream is subject to sudden floods. It also crosses a high divide over a narrow and somewhat dangerous trail known as the "Goat Trail." Furthermore, it is impassable on account of snow until early in July, and snows in the fall may block it by the 1st of September. To the cautious traveler the somewhat longer but safer Nizina-Skolai branch recommends itself.

At the head of Skolai Valley the two branches join, and a single trail extends for about 14 miles across Russell Glacier. For most of that distance the trail follows the moraine-covered portion of the glacier, winding back and forth over its irregular surface. Although the melting of the glacier affects the trail somewhat, rendering

certain portions impassable from time to time, so that short detours are necessary, the glacier crossing is not difficult and requires only five to six hours for pack horses. From the head of White River to the placer mines various routes may be followed through a rolling country with low passes, no difficulties being encountered other than some soft ground. One of these routes leaves White River near the mouth of Lime Creek and goes in a northwest direction across a high flat to the head of Gehoenda or Trail Creek and down that stream to Chisana River, at the town of Chisana. A branch of this trail leaves it near the head of Solo Creek and runs northward past Beaver Lake to the town of Bonanza.

COPPER RIVER-NABESNA ROUTE.

The Copper River-Nabesna route starts at the town of Chitina, on the Copper River & Northwestern Railway, 131 miles from Cordova. It follows the Government military road from Chitina up Copper River to Gulkana. From Gulkana a trail follows the north bank of Copper River to the Indian village of Batzulnetas, whence it takes an eastward direction to the head of Platinum Creek and follows that stream to Nabesna River. Crossing that river it follows Cooper and Notch creeks to Chisana River, 8 miles below the town of Chisana. By this trail the distance from Chitina to Chisana is about 235 miles, and the route is little used for summer travel. In winter, however, the greater distance is largely offset by the gentle gradient, the avoidance of glaciers, and the abundance of timber for fuel along the whole route. The only high pass to be crossed is Cooper Pass, an ice-free divide at an elevation of about 6,000 feet, approached by moderate grades. Considerable freight was taken over this route in the winter of 1913–14 in competition with the much shorter Nizina-Chisana route, although the sledding distance is nearly three times as great, and many freighters are said to contemplate a change from the Nizina-Chisana to the Copper-Nabesna route for future freighting.

DAWSON-WHITE RIVER ROUTE.

Many of the gold seekers in this district come from Dawson by way of White River. Freight may be taken by steamer up the Yukon to White River, a distance of about 70 miles, and by poling boats or shallow-draft power boats up White River as far as the mouth of Donjek River, or even to the mouth of Beaver Creek in favorable stages of water, and poling boats can be used to Canyon City, a village on White River a few miles below the international boundary. From White River freight is taken in winter by sled to the placer mines. A winter trail has now been cut from the mouth of Beaver Creek to the point where that stream first crosses the boundary, and this route is said to offer no great difficulties, although the distance by boat from

Dawson is about 175 miles to the mouth of Beaver Creek, and about 85 miles overland from the mouth of the Beaver to the placer mines.

TANANA-CHISANA ROUTE.

Upon the circulation of the report that rich placer discoveries had been made in the Chisana basin, a considerable number of men made their way up Tanana and Chisana rivers by launch and small boats. Under favorable conditions launches may be taken up these rivers as far as the north front of the Nutzotin Mountains, and boats were lined or poled all the way up to the mouth of Chathenda Creek. The route from Fairbanks, the base of supplies, is, however, long and difficult and, though possible, will never be an economical route for bringing in supplies. In the fall of 1914 many persons availed themselves of this water route and built boats in which they rowed downstream to Fairbanks.

WHITEHORSE-KLUANE ROUTE.

The route from Whitehorse to Canyon City by way of Kluane Lake is available for travel both in summer and in winter, though the winter trail makes some short cuts and is shorter than that used when the lakes are unfrozen. A wagon road has been built from Whitehorse to Lake Kluane, a distance of 143 miles, and a trail extends about 170 miles from the upper end of the lake to Canyon City, on White River, and thence 55 miles farther up Beaver Creek to the placer mines. The total overland distance by this route is therefore about 368 miles in summer and perhaps 20 miles less in winter.

COFFEE CREEK ROUTE.

Coffee Creek joins the Yukon 110 miles above Dawson. From the mouth of this creek a good trail has been built to the junction of Beaver Creek with White River, a distance of about 80 miles, and another branch leads to Canyon City, 120 miles by trail from the Yukon. From the mouth of Beaver Creek the trail to the Chisana placer mines reaches the Beaver at the international boundary and thence proceeds up the Beaver to its head. The total distance by this trail from the Yukon to the town of Bonanza is about 160 miles.

ACCOMMODATIONS ON THE TRAILS.

Along all the most used routes to the gold fields there were in 1913 and 1914 road houses at intervals of 15 to 30 miles at which meals and lodging could be procured. Thus along the Nizina-Chisana and Nizina-White River routes one could travel from road house to road house each day for the entire distance. On the Copper River-Nabesna route there are road houses along the Government military road as far as Gulkana. On the Whitehorse-Kluane route

road houses are maintained between Whitehorse and Kluane Lake, but none west of that portion of the trail. The rates charged at these road houses vary on the different routes and with the distance from established lines of transportation, but range from a minimum of $1 a meal and $1 for lodging to $1.50 or even $2 a meal in the more remote portions of the region.

VEGETATION.

Only a small portion of this area is timbered. Spruce trees grow along the lower valley slopes of Chisana and White rivers up to the glaciers in which these streams head, and the valleys of some of their tributaries also have some timber in their lower portions. In Chisana Valley, near the town of Chisana, trees 2 feet in diameter at the base were seen, but over most of the timbered portion of the district the trees do not commonly exceed 1 foot in diameter. At only a few places were trees seen above an elevation of 4,000 feet, and large areas below that elevation are untimbered. Much the greater portion of the region, however, is above timber line. In the placer camp wood for fuel and lumber for sluice boxes and other mining purposes must be brought several miles to the places at which it is to be used. Willow and alder brush grow in many places that are devoid of trees and furnish sufficient fuel for the prospector's camp, but in the area between upper Beaver Creek and White River and in all the higher mountain masses even small brush for fuel is almost entirely lacking, and for even the small requirements of a temporary camp wood must be brought from a distance.

Grass for horses may be found in favorable places throughout this region, although it is only locally abundant. Good forage for horses is specially plentiful in the valley of White River and on Beaver Creek near the mouth of Horsfeld Creek, and horses have passed the winter successfully at both places. In the spring the new grass appears about the first of June, and stock may be maintained on it until the heavy frosts begin early in September.

GAME.

Game was formerly abundant throughout the region but has now been greatly thinned out in the immediate vicinity of the mines. Elsewhere sheep are plentiful in the more rugged hills and mountains and furnish a valuable food of fine quality in this county where provisions are so difficult to obtain. Caribou, while less numerous, are easier to hunt and are fairly plentiful in the rolling country between Beaver Creek and White River. Moose are numerous in the White River valley near the boundary and occasionally range to other parts of the district. Black and grizzly bears are sometimes seen. Both rabbits and ptarmigan have been unusually abundant

during the last few years and have been killed in great numbers to supply food for both men and dogs. Some fur-bearing animals, notably fox, lynx, mink, and marten, are trapped each winter.

NATIVES.

This region as a whole is very sparsely peopled with Indians. A few families live in the vicinity of lower Beaver Creek and hunt and trap into adjacent territory, and there is a small settlement on Cross Creek, in the Chisana Valley. These natives had for a long time been little in contact with white men and supplied most of their simple needs from the products of the country. Now that a great influx of miners and prospectors has taken place it is probable that they will become dependent on the white man for a livelihood, as they have done at so many other places.

GENERAL GEOLOGY.

The rocks of the Chisana-White River district range in age from Devonian to Recent and comprise a wide variety of rock types, including all the common varieties of sediments and igneous rocks of many kinds, both intrusive and extrusive. In general it may be said that the portions of the St Elias and Wrangell ranges included in this region are composed dominantly of igneous rocks, with which are associated considerable quantities of sediments, and that the Nutzotin Range is composed primarily of sedimentary beds cut by dikes and intruded by large masses of crystalline igneous rock and contains also some surface lava flows. The surface lavas also cover a large area lying between the St. Elias and Nutzotin mountains.

In the reconnaissance surveys upon which this report is based only the more general features of distribution of the rock formations could be determined, and time was not available for a study of the many details of structure, character, and areal extent which are so important to a complete understanding of the geologic history of the area. Nevertheless, it is believed that the major geologic units have been separated with a fair degree of accuracy, and the paleontologic evidence obtained serves to confirm the conclusions reached in the field from structural and lithologic evidence. (See Pl. IX.)

The dominant rock structures of the district have a distinct northwesterly trend. This is the general strike of the Carboniferous rocks of the St. Elias and Wrangell mountains, of the Mesozoic sediments of the Nutzotin Mountains, and of the great fault which in general separates the Paleozoic from the Mesozoic rocks. Even in the Tertiary beds the strike, with local exceptions, is northwest, and all the major mountain-building movements that have been recognized are due to forces that have operated at right angles to this direction of structural trend.

The oldest rocks that have been recognized in this area are of Devonian and Carboniferous age. They consist dominantly of a great series of volcanic materials, including lava flows, interbedded with tuffs, and agglomerates of basaltic and andesitic character. For purposes of description these rocks in the aggregate will be grouped as "pyroclastic rocks" in the succeeding pages, following the usage of Moffit and Knopf [1] in their earlier report on this same general region. Associated with these pyroclastic rocks there is in many places a considerable amount of sedimentary rock, principally limestone and shale, but in general the sediments are subordinate in amount to the rocks of igneous derivation. At a single locality, near the mouth of Little Eldorado Creek, fossils were found which have been determined to be of Devonian age. This place is near the lowest exposed portion of the pyroclastic series and is the only place in the region at which rocks of greater age than the Carboniferous are known to occur. The rocks both above and below the fossil locality are pyroclastic rocks with interbedded shales and graywackes, similar to those which form a great portion of the Carboniferous series. In the field they were supposed to be Carboniferous and were not separated. Their areal extent is not known but is probably not large, and in this paper the Devonian at this place is included with the Carboniferous pyroclastic rocks for the sake of brevity in description.

On lower Skolai Creek, at several places in the White River valley, and on the north flank of the Wrangell Mountains there is a massive limestone which forms a conspicuous member of the Carboniferous section, in places reaching a thickness of several hundred feet. Locally the limestone carries abundant fossils, which give a definite determination of the age of the limestone and of the pyroclastic material with which it is interbedded. Both above and below the limestone there are locally developed thick beds of shale. The sedimentary portions of the Carboniferous are now discontinuous, for the whole series has been faulted and folded, but it is probable that the water-laid beds were once much more continuous than they are now and that their present patchy distribution is due, in part at least, to the deformation which they have suffered.

In addition to the great quantity of extrusive and fragmental matter which makes up a large part of the Carboniferous section, the bedded materials, both igneous and sedimentary, have been intruded at many places by bodies of granitic rocks, some of which are of large size.

The next younger system of rocks, the Triassic, is certainly represented in this region, although at present it is not possible to draw

[1] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska: U. S. Geol. Survey Bull. 417, 1910.

sharp lines of separation between the several Mesozoic formations. Fossiliferous thin-bedded Triassic limestones have been found on Cooper Creek, and it is possible that a great thickness of the unfossiliferous slates and graywackes of the Nutzotin Range may be of Triassic age.

The Jurassic beds consist of shales or slates, graywackes, conglomerates, and some thin limestones, the aggregation having locally a considerable thickness. Known Jurassic rocks occur in the Nabesna River basin and along the south flank of the Nutzotin Mountains, in the vicinity of the Chisana placer mines. At the latter locality they seem to grade insensibly into the slates and graywackes of the mountain range and to constitute an undetermined portion of that great series of sediments. Toward the south flank of the Nutzotin Mountains, near the placer camp, the Jurassic beds, although dipping at rather steep angles to the southwest, have been only slightly folded, and their structure is simple. A few miles to the north, in the higher mountains, the sediments have been intensely folded and crumpled, slaty cleavage has been locally developed, and the rocks as a whole have been much more severely altered and hardened than toward their southern margin. The Jurassic beds have in places, as on upper Chathenda and Bonanza creeks, been extensively cut by basic dikes.

Lower Cretaceous sediments have been recognized only within a small area in the neighborhood of the Chisana placer mines. So far as was determined, they appear to be structurally conformable with the Jurassic rocks and like them are composed predominantly of shales and graywackes. Apparently they were a part of a continuous series of beds deposited from Jurassic into Lower Cretaceous time. They carry rather abundant fossils of a single species, but only one or two species in all were found. Like the Jurassic, the Cretaceous beds are cut by numerous basic dikes and sills. Although in the vicinity of the placer mines the Cretaceous rocks directly adjoin the Carboniferous pyroclastic rocks and the granitic intrusions into the Carboniferous, the contact is not one of sedimentation, but the two formations have been brought together by a great fault, which is believed to extend generally between the older igneous rocks and sediments on the south and the dominantly sedimentary formations that make up the Nutzotin Mountains.

Sediments of Tertiary age occur in small areas at a number of places, surrounded by older rock formations. They consist of sandstones, shales, conglomerates, and some unconsolidated gravels, with locally some volcanic material in the form of agglomerates and tuffs, and at a few places they contain lignite. The lignite is generally in very thin beds or carbonaceous films and has no commercial value. At two localities beds of lignite occur in sufficient thickness to offer promise of yielding a moderate amount of fuel for local use.

Extensive areas are occupied by lava flows that have been considered to be of Tertiary age. The lavas cap the Carboniferous beds along Skolai Creek and west of Russell Glacier, as well as in parts of the Ptarmigan Creek basin, and are the prevailing rocks over much of the region between White River and Beaver Creek. They comprise dark basic lavas, some of which show well-developed columnar structure. In places these lavas have been warped and tilted, but in general they still preserve their original flat-lying attitude. Although the extrusion of this series of lavas probably began in Tertiary time, it continued at least into the Pleistocene epoch, and as Mount Wrangell is still a mildly active volcano, it may be that outpouring of lavas from this center has taken place in Recent time.

The deposits of Quaternary age consist mainly of the unconsolidated materials deposited by glaciers and by the present streams, and of talus and soil produced by the agencies of rock weathering and decay. In addition to these there are, as already stated, some lava flows interbedded with and overlying older glacial deposits, volcanic ash, and accumulations of organic material as peat or "muck." All the mountain valleys and much of the intermountain area of hills were formerly deeply covered by glacial ice, and the ice upon its retreat left in place a great amount of morainal material. The larger valleys of the Wrangell and St. Elias mountains still harbor great glaciers, and these constantly bring down quantities of rock débris. Some of this material is fed into the streams and transported for a distance, to be deposited on the stream flats in the form of great gravel trains, and some still remains near the borders of the glaciers as typical morainal deposits. As the mountain glaciers are still vigorous, as much of the detritus supplied to the streams is of glacial derivation, and as the glaciers have probably existed uninterruptedly from Pleistocene time to the present day, the extensive sand and gravel deposits of the present streams are of glaciofluvial origin, and the distinction between Pleistocene and Recent gravels can not be made.

The volcanic ash already mentioned is a persistent and conspicuous, though generally thin, member of the Quaternary deposits throughout this district.[1] Everywhere except in the regions of high, bare mountains, where erosion is rapid, a layer of this material may be found near the surface, in places covered by a few inches of moss. Near the placer mines it is present in a layer from a few inches to a foot thick, lying beneath a foot or so of muck. In the upper White River valley it is a few inches thick, but it becomes increasingly thicker to the east, toward the international boundary. Near the mouth of North Fork of White River the ash layer is 2 feet thick and lies beneath 7 feet of peat. The greatest thickness of this ash

[1] Capps, S. R., An ancient volcanic eruption in the upper Yukon basin: U. S. Geol. Survey Prof. Paper 95, pp. 59–64, 1915 (Prof. Paper 95-D).

observed occurs on the north flank of the St. Elias Range near Mount Natazhat. There the ash forms great drifts at the base of the mountains, is in places nearly bare of vegetation, and has been blown by the wind to form great dunes 200 feet or more in height. It seems probable that the crater from which the ash was ejected lies somewhere in the mountains near Mount Natazhat. Thomas Riggs, jr., reports a small crater in the basin of Kletsan Creek that may be the one from which the ash came.

The last great geologic events of importance in this district were the advance and retreat of glaciers, which pushed down from the mountains and covered all of this region except the highest mountain peaks. That portion of the country over which the ice moved was eroded and changed by the wearing of the thick ice masses; deep, broadly U-shaped valleys were formed, and a striking and characteristic type of topography was impressed upon the land surface. With the withdrawal of the glaciers to their present positions the streams again established courses on the glaciated surface, but in many places the land forms were so changed that the streams deserted their preglacial courses and found new channels, leaving their former valleys unoccupied by streams. These changes of drainage have had a strong influence upon the present distribution of placer deposits, and the recognition of these changes is essential to a proper understanding of the causes which have led to the concentration of gold in the places where it now occurs.

GOLD PLACERS.

GENERAL FEATURES.

The productive gold placer gravels of the Chisana district occur in the basins of Chathenda (Johnson) and Chavolda (Wilson) creeks, within a very small area. Exclusive of a few claims from which some gold was taken during prospecting operations, all the gravels which have been profitably mined can be included within a circle only 5 miles in diameter, with Gold Hill as its center. (See Pl. IX.) The valley of Bonanza Creek, the largest of the gold-bearing streams, has been found to contain workable gravels almost continuously from a point near its mouth, on claim No. 2, to claim No. 12, a distance of about 3 miles. The lower three claims on Little Eldorado Creek and the lowest claim on Skookum Creek have been profitably mined, Glacier Creek and its tributaries have yielded a moderate amount of gold, and Big Eldorado Creek has some gravels that contain valuable gold deposits. In the whole district mining was actively carried on during the summer of 1914 on about 21 claims, and a large number of other claims received varying amounts of attention from prospectors. An average number of about 325 men were employed in mining during the summer season.

MINING CONDITIONS.

One of the most important of the factors which determine the cost of mining in this region is the shortness of the season during which open-cut placer mining can be carried on. Placer operations are dependent on stream flow and can be commenced in the spring only when the streams have run free of ice. Moreover, except at those places where artificial thawing is employed, mining can be done only when the gravels have thawed. In the Chisana camp there is a considerable range in altitude between the claims on lower Bonanza Creek and those on the headward portions of the streams, and the lower claims may be mined in the spring before the snow is gone from those at greater elevations. In general, however, mining can be started between the 1st and 15th of June and continued until early in September, when the streams become low and ice begins to form. A period of only 90 to 100 days is therefore available for open-cut mining.

The short season and the remoteness of the district from established lines of transportation are reflected in the wages paid for labor. The current rate for common labor is reckoned at $10 a day, or $6 a day and board. This high price seems justified by the conditions in the district, yet much ground can not now be worked that would yield a profit if the labor cost were less.

No timber occurs near the placer mines, and wood for fuel and lumber must be brought from lower Chathenda Creek or from Chavolda Creek, a distance of several miles. Two sawmills at Chisana and one at Bonanza were in operation in 1914, at which spruce lumber could be obtained. The price charged at Bonanza was $150 a thousand feet, and at Chisana from $125 to $150 a thousand feet, but in addition to the sawmill prices the cost of transportation to the mines is high. Cordwood is said to bring $40 a cord delivered at the mouth of Little Eldorado Creek.

Only the simplest of mining tools or equipment could be purchased at the stores, and practically all appliances were brought in by the individual operators for their own use. It has therefore been necessary for each miner to know in advance what equipment he will need, so that it can be brought in by sled during the winter. The result of the isolation of the camp and of high freight charges is that only the simplest forms of mining have been conducted, and the gold is recovered almost entirely with pick and shovel.

ORIGIN OF GOLD PLACERS.

It will be noted on reference to the map (Pl. IX) that most of the placer deposits occur within the borders of the areas of Carboniferous pyroclastic rocks and of the granitic rocks that are intruded into the Carboniferous formations, the only exceptions to this rule being the

claims above No. 8, Bonanza Creek, and the rather low-grade deposits in the basin of Glacier Creek, all of which lie on a bedrock of Mesozoic sediments. It is also a well-established fact that the headward tributaries of Bonanza, Chathenda, and Chavolda creeks, which flow over Mesozoic sediments exclusively, have little or no placer gold. The exceptions to this rule—claims No. 8 to No. 13 on Bonanza Creek and the placers in the Glacier Creek basin—are all in close proximity to Gold Hill.

Gold Hill, a high, smooth-topped mountain, lies about in the center of the producing placer claims and is drained by Canyon, Bonanza, Little Eldorado, Skookum, Poorman, Glacier, and Big Eldorado creeks, a group comprising all the streams that have been shown to contain workable placers. It is capped by a gravel deposit, which apparently has a thickness of more than 200 feet and which lies upon the intrusive granitic rocks and the materials of the Carboniferous pyroclastic series. The material in the gravels is composed for the most part of pebbles derived from the Carboniferous and its intrusive rocks but contains also an appreciable admixture of Mesozoic sedimentary pebbles. The material is unconsolidated but is deeply oxidized and contains pieces of lignitized wood, and many of the pebbles are decayed. The gravel is believed to be of late Tertiary age.

Prospect holes have been sunk in the gravels of Gold Hill, and some gold has been found, though not in sufficient concentration to be mined. As will be shown later, there are in the Carboniferous rocks near by a number of lodes which carry free gold, and it is believed that the gravels of Gold Hill received their placer gold originally from these lodes, which occur in the area where the Carboniferous rocks are cut by granitic intrusive masses. The close association of gold lodes with granitic intrusive rocks has been shown so often in Alaska that no further discussion of this relation is necessary here.

The placer gold on Bonanza, Little Eldorado, and Skookum creeks and in the Glacier Creek basin is characterized by its smoothed, worn appearance and has apparently been subjected to considerable handling by stream action. It seems evident to the writer that this placer gold is the result of a postglacial reconcentration, probably of materials from Gold Hill, and that the bedrock source of the gold is the veins in the Carboniferous rocks.

The placer gold of Big Eldorado Creek is in striking contrast to that of the other producing streams. It is bright and angular and shows almost no evidence of stream wear. Much of it has quartz particles attached to it, and sharp-angled pyramidal crystals of gold are common. This gold appears to be a primary concentration, for if it had been much handled by streams its sharp angles and crystalline

faces would have been worn away. The gold placer mines on Big Eldorado Creek are all in that portion of its basin which lies entirely within the area of Carboniferous pyroclastic rocks and granitic intrusives, and if the angular gold is a primary concentration, its bedrock source must have been in the materials of those rocks or in veins which cut them.

The gravels of Gold Hill are but a remnant of a gravel deposit which in former times was certainly more extensive than it is now and which has been removed by stream and ice erosion from some areas over which it is no longer found. A relatively slight extension of the area of these gravels would carry them eastward over all the claims on upper Bonanza and Little Eldorado creeks which contain placers. The mines on lower Bonanza Creek and on Glacier Creek may also have been within the area of the gravel deposit, but they all fall in valleys which have headward tributaries in Gold Hill, and as the gold may have moved downstream to its present position, its presence can be explained without resorting to the supposition that the old gravels once extended over them.

D. D. Cairnes, as the result of a visit of a few days that he made to this district in the fall of 1913 in connection with his study of a near-by portion of Yukon Territory, published an account[1] of the general geologic and physical conditions of the camp. He describes the rocks as being dominantly sedimentary and mainly of Mesozoic age. This description applies to only the northern portion of the placer district, and Cairnes failed to recognize the Devonian and Carboniferous age and pyroclastic character of the rocks which underlie nearly all of the most productive ground, or the fact that a great fault separates the Mesozoic sediments from the Devonian and Carboniferous rocks below. He noted that the Mesozoic sediments at the heads of the Bonanza Creek tributaries in the Nutzotin Mountains are iron stained and somewhat mineralized and states that "From these mineralized sediments of the Nutzotin Mountains the gold of the Chisana placers has most probably been derived." At another place he states that "Prospectors and others searching for placer gold in these portions of Yukon or Alaska are accordingly advised to confine their attention primarily to those creeks which flow through the shales and slates of the Nutzotin Mountains, and particularly where these rocks are highly mineralized and colored red with iron stain, as they are at Chisana." With these views the present writer is not in accord. The distribution of the placer gravels, as already shown, seems to point conclusively to the source of the gold in the older Carboniferous and Devonian rocks. Furthermore, none of the streams which lie exclusively within the Mesozoic sediments, such as the heads of the Bonanza and Glacier creek tribu-

[1] Canadian Min. Inst. Bull. 24, pp. 33–64, 1914.

taries and of both Chathenda and Chavolda creeks, which drain the same mountain mass, show workable placer ground, and many of them, after rather thorough prospecting, have yielded not so much as a color of gold. On the other hand, veins in the Carboniferous rocks near granitic intrusives have been found to carry gold on Nabesna River, in the Chisana district; on Beaver, Horsfeld, and Eureka creeks, near the international boundary; and at other places. It is not intended to imply here that the Mesozoic sediments nowhere contain gold veins, or that they may not yield gold placers. Some small quartz stringers from these sediments have been found on assay to carry some gold, but so far as the writer has been able to learn no gold deposits of commercial value have yet been found which were unquestionably derived from the Mesozoic sediments of the Nutzotin Mountains.

The belief that much of the present placer gold is a secondary concentration from the lower-grade Tertiary gold-bearing gravels of Gold Hill implies great changes in the topography of the district since the older gravels were deposited. These older gravels now occupy the top of a prominent mountain and are surrounded on all sides by lower valleys. At the time the gravels were laid down, the present position of Gold Hill must have been low compared with the areas from which the gravels were derived. After the gravels were deposited, probably over an area much greater than that which they now cover, the processes of normal erosion, stimulated by mountain building and uplift, carved valleys below the level of the gravels, and these, too, suffered erosion. What gold they contained was concentrated in the streams and, probably, rich gold placers were formed. In the course of time the glacial period began and glaciers formed in the mountain valleys and grew and joined in the lowlands, until at the time of their greatest development only the high peaks and ridges of the mountains projected. Gold Hill and the other mountains between Chathenda and Chavolda creeks were completely submerged by glacial ice, the valley and canyon of Chisana River were filled by ice to a depth of over 2,000 feet, and the glaciers were continuous between Chisana, White, and Beaver valleys. The erosion by this thick body of slowly moving ice was enormous, and its effect upon the present topography is still preserved with striking vividness. The submerged hills were rounded and smoothed, and the valleys were widened and deepened. Whatever deposits of stream gravels existed before the ice advance, together with the gold placers which they may have contained, were eroded and in large part swept away and scattered by the glaciers.

With the withdrawal and shrinkage of the glaciers, the rocks were again exposed to stream cutting. The valley gradients had, however, been changed by the ice erosion, and the streams found conditions

greatly different from those which had existed in preglacial time. In reestablishing their courses the streams in general reoccupied their preglacial valleys, but in places the old valleys were deserted and new ones formed. By the lowering of their outlets some streams acquired high gradients and soon cut canyons through portions of their courses. This is particularly true of Bonanza, lower Little Eldorado, and Glacier creeks. The present inner canyons of these streams have certainly been cut since the valleys were modeled by glacial ice.

The placer deposits are therefore almost entirely the result of postglacial concentration, and the gold-bearing bench gravels which have been found at places within the canyons, but above the present streams, are not properly to be called "old channels," but are merely remnants of the gravels of the present streams left behind as the valley was rapidly lowered.

Cairnes [1] recognizes the youthfulness of the present canyons and says of the changes of drainage: "Such may have been produced by a somewhat sudden uplift of the district or by the glacial damming of portions of the stream valleys, caused by great accumulations of morainal material derived from the mountains to the north." He therefore does not seem to recognize that in glacial time, as at present, the great ice movement was not from the north, but from the Wrangell and St. Elias mountains northward, augmented by the smaller glaciers from the Nutzotin Mountains; that the whole of the mining district was completely buried by glacial ice; and that the present topography is in large measure that which was impressed upon the district by glacial erosion.

Cairnes speaks of bench or "old channel" gravels, and says: [2]

> As the bottoms of the old channels are in places above and in places below those of the streams of the present creeks which they cross, these older gravels now occur both as bench deposits above those of the present streams and as buried gravels below the level of the present stream bottoms. * * * It seems possible, from what is now known of the different gravels in the Chisana district, that the bulk of the placer gold in the district was or is [in] the old channels and will be obtained either from the gravels of the old channels directly, or from gravels of the present streams where these cut the older gravels.

After a season of vigorous mining and prospecting in 1914 no single deposit of gravels was seen by the writer which could properly be called an "old channel" deposit or which could not have been laid down by the present streams during the postglacial cutting of their canyons, except the Tertiary gravel capping of Gold Hill. It may be that there still remain portions of the stream deposits of the preglacial streams which were not removed by glacial scour, but if so they have not yet been found. In Dry and Alder gulches there is a heavy fill of gravels along an old glaciated valley, deposited when the present mouth of Chathenda Creek was blocked by Chisana Glacier, but this

[1] Cairnes, D. D., op. cit., p. 53. [2] Idem, p. 61.

valley was occupied by a stream for only a short time during the recession of the glaciers, and its gravels are not preglacial.

MINES AND PROSPECTS.

During the present investigation all the mines that were being actively worked and most of the prospects upon which work was being done were visited. In the following pages the mining operations are briefly described. The separate properties are described in order along the streams, those on each creek being grouped under one heading and the descriptions beginning with the lowest claim and proceeding in order upstream. A number of claims were worked under one management, and the description of the mining done by this company on all its ground is given at only one place.

BONANZA CREEK.

No. 1 FRACTION.

No. 1 Fraction is a fractional claim lying immediately above claim No. 1, through which Bonanza Creek flows for a distance of about 100 feet, in a steep-walled canyon. During periods of high water the stream occupies the canyon bed from wall to wall, and at ordinary stages of flow there are gravel bars of small dimensions at only a few points. Prospecting and mining were carried on here in a small way by one man, who confined his work for the most part to cleaning out the crevices of the agglomeratic bedrock and to washing out the small accumulations of stream gravels. The gold recovered had been scarcely sufficient to justify mining, but the varying tenor of the gravels on other parts of this stream encouraged the expectation that some richer spots might be found. There is insufficient workable ground here to warrant operations on an extensive scale.

DEADMAN FRACTION.

The so-called Deadman Fraction is a fractional claim about 950 feet long, lying between No. 1 Fraction and No. 2. Like No. 1 Fraction, it lies along that portion of Bonanza Creek which is steeply intrenched in a deep canyon of Carboniferous pyroclastic rocks. At the time of visit, late in July, 1914, a party of four men was just beginning mining operations, and no clean-up had yet been made, so that the value of the ground was not known. The canyon floor is narrow and if worked from rim to rim would give a width of bedrock of only about 12 feet, and the gravels are only from 2 to 4 feet thick. Large bowlders were abundant, and the quantity of gravel which could be shoveled into sluice boxes was small.

CLAIM NO. 2.

Mining was conducted during most of the open season on claim No. 2 by laymen, seven men being continuously employed. Sluicing was begun on June 12, no work having previously been done on this ground. The workable width of the canyon floor there averages about 30 feet, and no flume was used, the creek being diverted first to one side of the flat and then to the other. The usual pick and shovel method was employed exclusively. The gravels consist for the most part of rather flat, slabby cobbles and bowlders and range from 3 to 12 feet in thickness, averaging about 5½ feet. Water for the sluice boxes was taken from the creek through canvas hose, and the boxes were set on a grade of 9 inches to the box length. The gravels here contain little clayey sediment, and the use of a dump box has been found to be unnecessary. The gold is said to occur almost entirely on bedrock or in the crevices within the bedrock, no considerable amount being found in the overlying gravels. The gold is rather irregularly distributed on the bedrock, which consists of lavas and agglomerates, some beds being much decayed and soft. The harder phases of the rock are in places worn smooth and have retained little gold, but immediately below such places there are often found spots of considerable richness. The high points of the hard, rough bedrock have in general retained the most gold.

The gold recovered from this claim is coarse, but nuggets are rare, the largest found having a value of $4. All the gold is smooth and flat, showing plainly that it has been subjected to much wear between the place of its bedrock source and its present position. On August 1, 1914, about 500 linear feet of the stream bed had been worked out.

CLAIM NO. 3.

Claim No. 3 includes a deeply intrenched portion of Bonanza Creek, the canyon being cut into the Carboniferous pyroclastic rocks, which strike N. 75° W. and dip about 40° SW. Canyon Creek joins Bonanza Creek near the upper end of this claim. Mining operations were carried on by one party of 10 men. Work was commenced in the spring at the lower end of the claim, but the gravels there were found to average 14 feet in thickness and to be too low in gold content to justify mining. Mining was then begun at a point 600 feet below the upper line of the claim and progressed during the summer until the upper part of the claim was worked out. The ground mined averaged only 20 feet in width and ranged from 2 to 4 feet in depth. Large bowlders were very abundant. Many of them were too large to move by hand and were not taken from the cut, but the finer gravel was removed from around them. About 300 feet of 42 by 20 inch flume was used to carry the creek past the cut, and eight lengths of sluice box and a dump box, set on a grade of 10 inches to the box length and

equipped with pole riffles, were employed. The mining was all done by means of pick and shovel. The gold was coarse and well worn and was irregularly distributed, rich spots alternating with less productive areas. The highest values were commonly found on the higher portions of hard bedrock. In places where the bedrock was decayed and soft there was not enough gold to justify mining. Most of the gold lay on bedrock or in the cracks in it, and the gold content of the overlying gravels was said to be small.

NO. 3 A FRACTION.

No. 3 A Fraction is the lower of two fractional claims which lie between claims No. 3 and No. 4 and has a length of about 500 feet. On this ground six men were engaged in mining throughout the summer. Bonanza Creek is here deeply intrenched in the Carboniferous pyroclastic rocks, and the stream flat is winding and narrow, the workable ground having an average width of only 12 feet and a thickness of 2 to 8 feet. The stream was carried across the working cut by a flume 120 feet long and 42 inches wide, and the gravels were mined by pick and shovel and washed through a set of 12 sluice boxes and a dump box, lined with pole riffles and set on a grade of 10 inches to the box length. The gravels are not well rounded, and angular pieces of rock are common. A sticky clay mixed with the gravel makes the use of a dump box necessary, and even this fails to disintegrate all of the clay so that some loss of gold must certainly take place. Much of the bedrock is hard and blocky and retains the gold well, and most of the gold occurs on bedrock or in the crevices in it. It is necessary to take up from 2 to 5 feet of bedrock in order to recover all the gold. As on many of the claims on lower Bonanza Creek, the best values are found not in the deepest channel in bedrock but on the higher points of it. The gold is bright, coarse, flat, and well worn. The largest nugget had a value of $61.80, and half of that recovered is said to be in nuggets worth $5 or more. Some pieces having a rusty, reddish coating are found on portions of the bedrock which are decayed and of a bright-red or purple color, the gold doubtless acquiring a rusty cast from the iron in the underlying bedrock.

3 B FRACTION.

The claim known as the 3 B Fraction is the upper of the two fractional claims lying between No. 3 and No. 4 and is about 900 feet long. Mining was begun on the lower end of this ground in 1913, and several thousand dollars' worth of gold was recovered. In June, 1914, mining operations were continued at the point where they were left off the fall before, and 10 men were continuously employed during the open season. The creek there flows through a deeply intrenched gorge in the Carboniferous lavas and agglomerates, and the bedrock is rough enough to retain the gold well. The creek

gravels average about 25 feet in width and are shallow, the average depth to bedrock being less than 2 feet. Although bowlders are rather abundant, most of them can be moved by hand and only a few require blasting. A flume 30 by 19 inches in section and 350 feet long is used to carry the creek past the cut and is adequate except in periods of flood. The pick and shovel method of mining is used exclusively, the gravels being washed through a set of 16 sluice boxes, each 12 feet long, 14 inches wide, and 12 inches deep, set on a grade of 8 inches to the box length and equipped with pole riffles. An abundance of sticky clay in the gravels requires the use of a dump box, and even this fails to disintegrate the clay completely, so that there is a constant loss of gold, equal, it is estimated, to about 10 per cent of that recovered. About 2 feet of bedrock is taken up and put through the boxes. The gold is practically all found on bedrock or in the cracks in the rock surface, the overlying gravels containing very little gold. The gold, which assays $16.36 an ounce, is bright, smoothly worn, and very coarse, the pieces averaging 10 to 15 cents in value, exclusive of the larger nuggets. One $40 nugget was found, and another worth $33.50, and pieces having a value of $3 to $20 constitute a large portion of the gold recovered. At the time this claim was visited it was said that the ground mined had carried an average value of about $2 to the square foot of bedrock.

A number of localities along the valley sides of this claim have small deposits of bench gravel, and the ground on which the tents are situated, 15 feet above the creek, is said to contain a good pay streak.

OPERATIONS BY F. T. HAMSHAW.

The claims staked in this district by James & Nelson, the original discoverers of placer in this camp, were leased by them to J. J. Price and J. J. Ives, who in turn assigned their lease to F. T. Hamshaw. The ground involved in these leases included, on Bonanza Creek, Discovery claim, No. 1 below and Nos. 1, 4, 5, 6, and 8 above Discovery; on Little Eldorado Creek, No. 1; and on Big Eldorado Creek, Discovery claim. With the exception of a few small subleases made by Price & Ives, all the mining done on these claims in 1914 was carried on by Mr. Hamshaw, the principal operations being on claims Nos. 4 and 5 on Bonanza Creek and No. 1 on Little Eldorado Creek.

The main camp was located on the south side of Bonanza Creek at the mouth of Little Eldorado Creek and consisted of about 16 tents in all, including offices, commissary, mess, and sleeping quarters. The camp is connected by fair trails and by telephone with the town of Bonanza, at which there is a general warehouse. The number of men employed varied considerably during the season, ranging from a minimum of 30 to a maximum of over 100. The general mining practice followed was to ground-sluice off the upper portion of the

creek gravels, leaving a foot or two above bedrock to be shoveled into the sluice boxes. Whenever a large gang of shovelers was employed, a horse team and scraper were used to clear away the tailings from the lower end of the sluice line. The average thickness of the stream gravels mined, including that portion of the bedrock which was removed, was only a little more than 6 feet, and the actual average thickness of the stream gravels was between 4 and 5 feet.

The following summary of mining operations on these claims is published because it is believed to contain valuable data on the actual cost of pick and shovel placer mining of shallow stream gravels in a region remote from established lines of transportation. Reliable figures on such operations are difficult to obtain, as they are rarely kept by the placer miner. Other operators in this same district claim lower mining costs than those given in the accompanying table, but their figures are not based on accurate measurements and can, therefore, not be given for comparison. It will be noted that the total working cost as shown would be somewhat reduced when proper account is made of the difference between the estimated and actual cost of board for the employees but would be increased if allowance were made for amortization, and if the cost of dead work were added.

Summary of mining operations by F. T. Hamshaw at Chisana, in the White River mining district, Alaska, during 1914.

[Published by permission of F. T. Hamshaw.]

	Linear feet of creek worked.	Value per linear foot.	Working cost per linear foot.	Square feet of bedrock mined.	Value per square foot of bedrock.	Working cost per square foot of bedrock.
No. 4, Bonanza	979	$22.17	$19.12	19,725	$1.23	$0.74
No. 5, Bonanza	833	26.45	20.13	23,182	.80	.67
No. 1, Little Eldorado	1,029	50.50	13.28	43,047	1.21	.32
Total or average	2,841	33.04	17.51	85,954	1.08	.576
Upper end of Little Eldorado Creek [a]	380	3.435	4.45	11,642	.14	.18
Operations of laymen	.....	.....	.....	24,904	.55	.37
Grand total	.....	.....	.....	122,500	.....	.....

	Cubic yards of gravel moved.	Value per cubic yard.	Working cost per cubic yard.	Gold production.	Total working cost.
No. 4, Bonanza	4,530.0	$5.51	$3.21	$24,128.00	$14,787.20
No. 5, Bonanza	5,619.5	3.65	2.73	20,528.00	15,473.00
No. 1, Little Eldorado	9,219.5	5.63	1.48	51,952.00	13,610.70
Total or average	19,369.0	4.93	2.473	96,608.00	43,870.90
Upper end of Little Eldorado Creek [a]	1,391.0	1.25	1.56	1,646.00	2,177.80
Operations of laymen	3,222.0	4.22	2.85	13,697.06	.....
Grand total	23,982.0	.....	.....	111,951.06	.....

[a] Not in pay channel; worked out to make dumping ground for pay streak on left bench.

NOTE.—Labor is calculated at $6 a day and board, or $10 a day. Boarding-house account shows a cost of $2.75 per day per man. Working cost does not include amortization and dead work, as follows: Cost of sluices, flumes, dams, and dead work before sluicing, No. 4, Bonanza, $5,280; No. 5, Bonanza, $4,975; No.1, Little Eldorado, $3,527; total, $13,782.

The gravels mined lie on bedrock composed of the Carboniferous and Devonian lavas and pyroclastic rocks, with some shales, all having a general northwest strike and dipping 10°–60° SW. The bedrock differs in character from place to place, some beds being much decayed and soft, while others are hard and rough. Throughout all this district experience has shown that the greatest concentration of gold occurs on the hard, rough bedrock, the softer phases being relatively lean. Bowlders in the gravels are rather abundant, although those too large to be rolled aside by hand are uncommon. In general the gravels are unfrozen, but locally frozen patches were encountered, and many of these were subleased to laymen to be mined.

The gold is bright, coarse, and smoothly worn. The largest nugget found had a value of over $130, and pieces weighing a quarter of an ounce or more make up about 5 per cent of the total gold recovered. The gold is said to assay $16.67 to the ounce.

The present stream gravels on claim No. 1, Little Eldorado, were about worked out during the summers of 1913 and 1914, but it is reported that late in the fall of 1914 rich ground was found on the left bank of Little Eldorado Creek several feet above the stream, and extending beneath the bench gravels at that place. On claim No. 5, Bonanza, paying ground was found high on the north valley wall, and at a number of places along both Bonanza and Little Eldorado creeks there are patches of bench gravels that have yielded good prospects.

CLAIM NO. 7.

Mining was carried on by two parties on claim No. 7. On the lower half of the claim four men were mining by pick and shovel methods. The creek there flows through a narrow gorge with steep walls of pyroclastic rocks interbedded with black shales. No flume was used, the creek being turned first to one side of the flat and later to the other. Ten lengths of sluice boxes, 12 by 14 inches in cross section, and a dump box were employed for washing the gravels, and in order to obtain sufficient grade for the sluice its upper end was set so high that in parts of the cut the gravels were lifted by shovel as much as 10 feet. A relatively small amount of ground required to be shoveled, for the surface gravels were first sluiced off by the use of an automatic dam before shoveling was begun. Water was carried to the sluice boxes by means of canvas hose. The gold was unevenly distributed, rich areas of hard, rough bedrock being succeeded by nearly barren stretches of smooth, decayed bedrock. The gravels washed were from 3½ to 4 feet deep and contained few large bowlders.

At the time of visit, in July, 1914, the operators reported that the output from this claim, which lies adjacent to the rich ground on Little Eldorado Creek, was disappointingly small.

On the upper half of No. 7 a number of men were engaged in mining, several hundred linear feet of the creek bed being worked out. Conditions were similar to those on the lower half of this claim, the distribution of the gold, however, being especially irregular. The gravels had an average width of about 20 feet and a depth of 3½ feet and contained an unusual quantity of sticky clay which made recovery of the gold difficult. Late in July the tenor of the gravels then encountered had become too low to justify mining, and a prospecting ditch 100 feet long had been run without having again encountered workable ground.

NO. 7 A FRACTION.

Mining was conducted on the lower of two fractional claims lying between No. 7 and No. 8, known as No. 7 A Fraction, which is between 500 and 600 feet long. Four men, as laymen, were mining gravels which averaged less than 2 feet in thickness. At the time of visit a section of the stream gravels 300 feet long and 20 feet wide had been worked out. Five lengths of 12-inch square sluice box and a dump box were used, with the upper end of the sluice line 9 feet above bedrock, the water being conducted to the boxes through canvas hose. Not many large bowlders were encountered, but numerous large pieces of angular rock were embedded in the gravels. The bedrock consists of the pyroclastic materials and some shales and in places is worn so smooth that little gold was retained on its surface. The gold occurred for the most part on bedrock or in the rock crevices, and the overlying gravels contained little. The distribution of the gold was uneven, relatively lean areas being succeeded by richer spots.

NO. 7 B FRACTION.

No. 7 B Fraction is a fractional claim about 700 feet long, lying between No. 7 A Fraction and No. 8. Four men had been mining on this claim, the title to which is in litigation. In an area 200 feet long and from 14 to 20 feet wide, which had been worked, the gravels averaged about 3 feet in thickness. The bedrock is composed of pyroclastic materials, and the richest ground was found on the harder portions of it, some of the ground yielding $2 to the square foot of bedrock. The distribution of the gold was very irregular, and late in July, 1914, the ground sufficiently rich to mine had been worked out and mining was discontinued.

CLAIM NO. 8.

On claim No. 8 mining was conducted by laymen for a part of the summer, and a stretch of the creek gravels about 400 feet long and having an average width of 12 feet was worked out. The gravels, of an average thickness of 3 feet, lay on a bedrock composed of pyroclastic materials. For several weeks 16 men were employed in two

shifts, 8 men working on each shift. Late in July the gold content of the gravels encountered became so low that active mining was discontinued, although 2 men were engaged in the endeavor to locate more ground which would warrant exploitation. The gold was said to be very unevenly distributed along the course of the valley floor and only locally to be abundant enough to justify mining under the present high cost of operation. The recovery ran from 10 to 22 cents to the square foot of bedrock. Practically all the gold was found on bedrock, the overlying gravels being of low tenor. There was considerable clay in the gravels, and although this clay contained some fine gold, the gold could not be recovered by the methods used. The largest nugget found on the ground had a value of $8, and the gold would all be classed as coarse, though large nuggets were much less common than on the next few claims below.

CLAIM NO. 10.

Two parties were mining on claim No. 10, one on the lower and one on the upper half of the claim. On the lower half four men, operating on a lease, were engaged in mining, although at the time of visit little ground had been sluiced. This claim lies above the contact between the pyroclastic rocks and the Mesozoic shale series, and the bedrock is composed of black shale, cut by numerous dikes. The gravels mined had an average thickness of about 4 feet, and the gold was for the most part on the surface of the bedrock, or less than a foot down into the crevices in it. The gravels are of comparatively small size and are easy to mine, few large bowlders being encountered. The gold is relatively fine and flaky, the only two nuggets recovered having values of $6 and $3.

On the upper half of the claim five men began mining late in July, 1914, and at the time of visit no sluicing had been done. A horse scraper was used to remove the surface gravels, but the sluice boxes had not yet been installed. It was said that the gold values all lay in the lower 3 feet of gravels and on bedrock, and that the gold content of the upper gravels was too low to warrant sluicing. The bedrock is black shale striking N. 65° W. and dipping 57° SW. The shales are cut by dikes which strike approximately parallel with the shale but dip at right angles to it.

CLAIM NO. 11.

On the lower end of claim No. 11 four men were prospecting in July, 1914, but had found no workable ground. The gravels were from 3 to 5 feet deep and lay on a bedrock of black shales with some interbedded sandstone, striking N. 55° W. and dipping 60° SW.

On the upper half of the same claim several men were beginning mining operations late in July. The gravels from a cut 4 to 5 feet in depth had been shoveled into the sluice boxes, but no clean-up had

yet been made. It is reported that late in the summer ground yielding $6 per square foot of bedrock was found on this claim, and that one nugget valued at about $64 and others worth $30 were obtained.

CLAIM NO. 12.

Three men, operating on a lease, were mining on the lower half of claim No. 12 in 1914. The gravels average about 5 feet in thickness, though they are locally as much as 9 feet thick, and lie on a bedrock of black shale. Wheelbarrows were used to take off the upper portion of the gravel, in which, it is said, not a color of gold could be found. The gravels are composed largely of rather flat pebbles of moderate size, and large bowlders were not abundant. The gold recovered was coarse and contained nuggets which had a maximum value of $8. No fine gold was found.

Three men were mining on the upper half of claim No. 12 and had sluiced the gravels from a cut 85 feet long and 18 feet wide. The gold found, almost entirely on the shale bedrock, was irregularly distributed but was said to average 60 cents to the square foot of bedrock. From 1½ to 2 feet of the bedrock was taken up to secure all the gold. The flow of water in Bonanza Creek at this place was just about sufficient to afford a sluice head.

UPPER BONANZA CREEK.

Late in July, 1914, no active mining was being done on upper Bonanza Creek, although prospecting was being or had been done at a number of places. On claim No. 13 one party had done considerable work, and it was reported that ground sufficiently rich to mine had not been found, although locally the returns were encouraging. Another party was just starting to prospect this ground.

Claims Nos. 14 to 18 have all received some attention from prospectors. On claim No. 15 several hundred feet of bedrock drains had been dug, but only an occasional color was found. On claim No. 18 there is a shaft said to be 85 feet deep, with a 25-foot drift from the bottom. The drift is on bedrock, but the bottom of the bedrock channel was not reached. No paying ground was found at this place.

LITTLE ELDORADO CREEK.

CLAIM NO. 2.

Active mining was conducted during the entire summer on claim No. 2, Little Eldorado Creek, seven men being employed. On this claim the stream flat, though bordered by steep bluffs, is wider than on the claim below, having a width of 75 to 150 feet. The gravels average about 3 feet in depth, contain few bowlders, and are composed largely of flat, shingle-like pebbles of banded shale and graywacke. The bedrock is of the pyroclastic series and is locally termed "porphyry." Its surface below the stream gravels is fairly flat in

cross section from one bluff to the other. The bedrock is much broken, and from 5 to 12 inches of it is shoveled into the sluice boxes with the overlying gravels. It is easily removed, as it comes up in angular fragments only a few inches in diameter. The gold is said to be recovered in large part from the bedrock, although the overlying gravels contain some gold. They are about 3½ feet deep throughout the claim, except in those places where detritus from the bluffs has moved down upon the stream gravels. At the time of visit 17 lengths of 11-inch sluice box, set on a grade of 8 inches to the box length, were in use, more boxes being gradually added as mining progressed upstream. The gravels contain little clay, and a dump box is not considered necessary here. The pay streak is 36 to 40 feet wide and is taken out in three cuts. Water under pressure is brought through canvas hose to the lower end of the sluice boxes, and a nozzle is so set as to keep the tailings from piling up at the end of the sluice line.

The gold is very coarse, a large percentage of that recovered being in nuggets ranging in value from 50 cents to $20. It is bright yellow in color and fairly well worn and is said to assay $16.90 to the ounce.

CLAIM NO. 3.

Mining was commenced in July, 1914, on claim No. 3 by three men and continued during the summer. At the time of visit a cut 65 feet long, about 50 feet wide, and averaging 3 feet in depth had been worked out. The gold was recovered from a false clay bedrock, underlain by 2 feet of gravels which rest on the true bedrock of lavas and intrusive rocks. The gravels are frozen at a depth of 2 feet below the surface and are stripped and thawed by water before being shoveled into the sluice boxes. They consist for the most part of shale and graywacke pebbles, with considerable material of various sorts which resembles the gravels found on Gold Hill. The gold, like that on claim No. 2, is bright and coarse, the largest nugget recovered having a value of $15.

SKOOKUM CREEK.

Skookum Creek is a small stream that joins Little Eldorado Creek from the west about 400 feet below the upper end of claim No. 2. The upper basin of this stream is a broad marshy tract lying on the east slope of Gold Hill, without conspicuous drainage lines. For the lower quarter mile of its course the creek flows through a well-defined though small gulch which shows outcrops of intrusive rock at a number of places, and the stream gravels lie on a bedrock, locally called "porphyry," which is composed of lavas and agglomerates, cut by later intrusive rocks. Six men were engaged in mining on the lower end of Skookum Creek throughout the summer of 1914. Work was begun near the mouth of the creek on ground which lies on claim

No. 2, Little Eldorado, and continued upstream onto claim No. 1, Skookum, the ground on both claims being operated on lease. At the time of visit, late in July, a strip of gravels 224 feet in length along the creek had been mined. The pay streak was narrow, averaging only 6 feet in width, but was unusually rich. The stream wash, consisting largely of rather angular material, is from 5 to 14 feet in thickness and averages about 6 feet. It contains also a considerable admixture of rounded gravels probably derived from Gold Hill. Numerous pieces of lignitized wood have been found during the mining operations. Both the stream wash and the bedrock were frozen. They were thawed by stripping and by surface water before they were shoveled into the boxes. Skookum Creek carries only a small volume of water, and even with an additional supply obtained from a ditch toward the head of Little Eldorado Creek only about one-third of a sluice head was available, and it was necessary to store the water and to sluice only intermittently. The gold occurs for the most part upon bedrock and is very coarse, little fine gold being recovered. The largest nugget found had a value of $52, and pieces worth from $10 to $20 were numerous. The gold is said to assay $16.50 to the ounce.

At the head of the cut, on August 1, 1914, the pay streak had widened to about twice the average width below, and on one side of the creek it was covered by 14 feet of overburden, of which 6 feet was nearly pure ice.

No prospecting had been done on Skookum Creek above the location of the mine.

GOLD RUN.

CLAIM "NO. 2 BELOW."

Claim "No. 2 below" on Gold Run, the lowest claim on that stream which had been mined, lies a short distance above the mouth of Glacier Creek. The stream has there a rather deep, narrow valley cut in shales, graywackes, and fine conglomerates, which form the bedrock of the gold-bearing gravels. Six men were mining on this claim throughout the summer with pick and shovel. By August 1 a strip of ground 150 feet long and 15 feet wide had been mined. The gravels range from 4½ to 5 feet in thickness and are for the most part composed of imperfectly rounded slabs of shale and graywacke, with a smaller proportion of well-rounded lava and diorite pebbles like those of the gravel capping on Gold Hill. From 1 to 4 feet of bedrock was also taken up and washed. Nine lengths of sluice box and a dump box, set on a grade of 8½ inches to the box length, were used. The gold is found both on bedrock and distributed through the overlying wash, is bright and fairly well worn, and is in finer and more flaky particles than that found on Bonanza Creek. The largest

nugget taken from this claim was worth $6.50. Operations on this claim are said to have yielded little more than the cost of mining.

CLAIM "NO. 1 ABOVE."

Mining operations were begun late in July, 1914, on claim "No. 1 above" Gold Run, four men being employed. Winter shafts had shown that bedrock lay about 14 feet below the surface and that an encouraging amount of gold was present. A pit 500 feet long and 40 feet wide was therefore ground-sluiced through about 11 to 15 feet of frozen gravel, but no sluicing had been done by August 3. As the water supply from Gold Run was too small for efficient mining, a dam was built to impound water for ground-sluicing and a ditch half a mile long to tap the upper part of Discovery Pup was under construction. It was thought that with this additional water supply sluicing could be started. The gravels are made up of poorly rounded shales and graywackes, with much well-rounded material derived from the gravels of Gold Hill. Few bowlders too large for two men to handle were encountered. The gold is said to be distributed throughout the gravels, without any noticeable concentration on bedrock.

CLAIM "NO. 2 ABOVE."

On claim No. 2 above Discovery, well toward the head of the Gold Run basin, one man was engaged throughout the summer in prospecting the benches 10 to 15 feet above the creek. The bedrock is composed of much fractured and broken shale and graywacke, covered by a mixture of shale fragments and rounded pebbles evidently derived from Gold Hill, against which this creek heads. Gold occurs in the detritus from the surface down but is most abundant in the shattered bedrock. It is for the most part fine and flaky, but a few larger pieces worth as much as $4 have been recovered. Some gold has been found in the creek bed on this claim, but the amount was insufficient to justify mining. The stream at this place is of small volume, and mining can be conducted on only a small scale.

POORMAN CREEK.

On claim No. 1, near the mouth of Poorman Creek, four men were mining throughout the summer. The stream flows in a narrow, steep-sided gulch cut through shales and graywackes intruded by dike rocks. The stream flow is normally too small to furnish a sluice head of water, and two dams were constructed to store water. Sluicing was therefore done only intermittently. The stream wash ranges in thickness from 4 to 12 feet and averages about 7 feet, and a section of the stream bed 100 feet long and from 10 to 15 feet wide had been mined. Nine lengths of sluice boxes, set on a grade of 13 inches to

the box length, were in use. The gold occurs both in the gravels and upon bedrock, of which about 2 feet is taken up and sluiced. The gold is fine and flaky compared with most of that recovered in this district, the largest piece having a value of only 35 cents. It is reported that the gold taken from this claim was insufficient in quantity to justify further mining.

BIG ELDORADO CREEK.

CLAIM NO. 4 BELOW UPPER DISCOVERY.

On claim No. 4 below Upper Discovery, Big Eldorado Creek, two men were mining on leased ground in 1914. On this claim the creek has cut a deep, narrow gorge into a mass of diorite, and the stream flat is steep and narrow, with many large bowlders. The stream gravels average 6 feet in thickness, and 4 feet of the surface material was ground-sluiced off before shoveling was begun. A pit 600 feet long and 12 feet wide had been mined. Most of the gold recovered was taken from the surface of the bedrock or the fractures in the rock, from 2 to 4 feet of the diorite being taken up and washed. The gold is unevenly distributed along the creek bed, fairly rich spots being succeeded by lean areas. The gold is bright and very rough. The operators reported that this claim yielded only a fair return for the labor expended on it.

CLAIM NO. 3 BELOW UPPER DISCOVERY.

Vigorous mining was conducted on claim No. 3 below Upper Discovery, 10 men, operating in two shifts, being employed. Big Eldorado Creek is here intrenched into the valley floor and flows through a narrow gorge cut in diorite, which forms the bedrock of the placer gravels. About 250 linear feet of the creek bed had been mined to an average width of 30 feet, the stream gravels there averaging only 2 feet in thickness. The gold-bearing gravels, while containing a good deal of angular material, are better rounded than those farther upstream and contain some well-worn gravels, probably derived from the ancient gravels that were formerly distributed along the hilltops adjoining this basin. Large bowlders of diorite of local derivation are common. Some gold is said to occur throughout the gravels, but the richest concentration is on the rough bedrock surface or in the crevices in the diorite. From 2 to 4 feet of the diorite is removed in mining. The gold is bright, coarse, and very rough. Few pieces were seen that showed signs of much wear, and most of the particles are angular and sharp, some crystal faces being discernible. Many pieces show the imprint of the crystals of vein quartz upon them, and gold with some quartz attached is common. The gold is markedly different in appearance from the well-worn, smooth gold of Bonanza and Little Eldorado creeks, and it is evidently of local

origin. The present creek placer is probably a primary concentration of gold derived from the rocks that form the upper basin of this stream.

CLAIM NO. 1 BELOW UPPER DISCOVERY.

Two men, operating on leased ground, were mining on claim No. 1 below Upper Discovery. The stream gravels average about 7 feet in depth and consist of a mixture of angular blocks and well-rounded pebbles. Large bowlders are not numerous, and most of those encountered could be handled without difficulty. The gold occurs mostly on bedrock, but some is distributed through the gravels. It is coarse, bright, and rough and shows little evidence of stream wear.

UPPER DISCOVERY.

Upper Discovery claim lies in the upper basin of Big Eldorado Creek. The valley of the stream is here a broadly U-shaped basin, and the creek has intrenched itself but little into the valley floor. Two men were prospecting this ground early in August. They reported many fine colors of gold throughout a vertical thickness of 10 feet of stream gravels, with a few small nuggets. The underlying rock is diorite, but the so-called bedrock in the cut made was a tough layer of clay, and no hard bedrock had been uncovered. The stream wash consists of bowlders and angular pieces of diorite intermingled with a goodly proportion of well-rounded gravels from Gold Hill. The ground is frozen and must be thawed before it can be sluiced. Insufficient sluicing had been done to afford a basis for reliable estimates of the value of this ground.

CHATHENDA CREEK.

Prospecting and some mining were done by two men on the Big Seven claim, on Chathenda Creek (locally called Johnson Creek) a short distance above the mouth of Rhyolite Creek. At that place Chathenda Creek flows in a deep, steep-walled canyon, cut through Tertiary sandstone, conglomerate, and shale and later gravels. The stream gravels average 4 feet in thickness and lie on a bedrock of sandstone. The south wall of the canyon is composed of a great thickness of gravels and shaly sand, and it is said that occasional colors can be found in these gravels and that the only stream gravels which carry encouraging amounts of gold are those immediately below the gravel bluffs. Considerable prospecting had been done, but little sluicing. The gold is rather fine and is unevenly distributed. The largest piece found had a value of $2. Numerous nuggets of native copper have been found in the stream gravels. Mining in this canyon is difficult on account of the large volume of Chathenda Creek, which in times of high water can not be controlled by ordinary means.

PROSPECTS.

Practically all the streams for many miles in each direction from this placer camp have been more or less thoroughly prospected, with varying degrees of success. In many places where little or no gold was found the prospectors have abandoned the ground and moved to other places, and the only evidence of their work is that given by the prospect holes and ditches which they excavated. Naturally the streams nearest to the rich placers of Bonanza and Little Eldorado creeks received the greatest share of attention, for all the adjacent streams were staked during the stampede late in the summer and fall of 1913. Thus Chathenda (Johnson) Creek was staked from the town of Chisana to the head of the stream, and numerous pits and cuts were made. It is worthy of note that in spite of rather thorough prospecting, Chathenda Creek above the mouth of Bonanza Creek has nowhere yielded even an encouraging prospect, and many of the excavations failed to show even a color of gold, although the stream lies parallel to and only a short distance south of Bonanza Creek and is eroding the same geologic formations. Below the mouth of Bonanza Creek the Chathenda gravels as far west as the mouth of the lower canyon are known to carry varying amounts of gold, and locally they have been rich enough to encourage extensive prospecting and even a small amount of mining. Several men prospected continuously throughout the summer of 1914 at points between the mouth of Dry Gulch and the lowest canyon.

Snow Gulch, a tributary of Little Eldorado Creek from the northeast on claim No. 2, is reported to contain workable gravels, both in the creek bed and on the benches, but mining there is being delayed until a suitable dumping ground shall be made available by the exhaustion of the gravels in claim No. 2.

The upper portion of Bonanza Creek and its tributaries, Coarse Money and Shamrock creeks, while only partly prospected, have as yet revealed no pay streak. Snow Gulch, Bug Gulch, and Pensive Pup, tributaries of Little Eldorado Creek from the northeast, have not yet been thoroughly prospected, but it is said that workable ground has been found on Snow Gulch. The benches along these streams and along Little Eldorado and Bonanza creeks are known to carry considerable gold locally and deserve further prospecting.

The valleys of Dry Gulch and Alder Gulch and the broad pass connecting them are known to be floored by a heavy deposit of gravels. In Alder Gulch and upper Dry Gulch several shafts, two of which are said to be more than 60 feet deep, penetrate gravels without reaching bedrock. The gravels are reported to carry some gold. Near the mouth of Dry Gulch a shaft 92 feet deep penetrates through gravels almost to the level of Chathenda Creek, without reaching

bedrock. This shaft is reported to have cut two layers of gravel which are sufficiently rich to warrant mining, but no gravels from this place had been sluiced.

Bryan Creek, the next tributary of Chisana River south of Chathenda Creek, was prospected in 1914. On claim No. 4 below Discovery six men were working throughout the summer. A number of pits were sunk, and a drain 10 feet deep was excavated without reaching bedrock. Some gold occurs throughout the stream gravels and especially on a clay false bedrock, the largest piece found having a value of $1.26. Copper nuggets are abundant. No sluicing had been done, and the work was all directed toward the endeavor to reach bedrock, in the hope of finding a valuable pay streak.

On claim "No. 3 below," Bryan Creek, one man had dug a long bedrock drain in gravels which were in places 12 feet in depth. The bedrock of sedimentary and intrusive rocks showed some gold, but no paying ground had been found at the time of visit.

The main valley of Chavolda (Wilson) Creek has been prospected at a number of places, with very little success. There are high bluffs of washed gravel on the south bank of the stream both above and below the mouth of Glacier Creek, but a tunnel driven 65 feet into the gravel bluff, with a 15-foot winze, is said to have yielded only a few fine colors. Other prospects farther upstream have given no encouragement. It is reported that during the winter of 1914–15 encouraging prospects were found on Chavolda Creek near the mouth of Alder Gulch.

Glacier Creek proper and its northeastern tributaries, Sargent, Paulson, and Chicken creeks, have not yet been proved to contain profitable gravels, although the southern tributaries, Gold Run and Poorman Creek, have yielded some gold.

Numerous tributaries of Beaver Creek and White River have been visited and prospected to a greater or less extent as a result of the stampede to the Chisana. It was reported that late in the fall of 1914 workable placer ground was found on lower Ptarmigan Creek, a northward-flowing tributary of Beaver Creek near the international boundary, but this report has not been verified. Lime Creek, a headward fork of White River, was the scene of one or two stampedes, but only small amounts of gold were found.

The possibilities of the general district near the headwaters of White and Chisana rivers have by no means been exhausted, and much unprospected ground remains which may prove to carry gold placers; but it is nevertheless significant that the large amount of prospecting that was done in 1913 and 1914 failed to enlarge greatly the area of productive ground, as determined during the early days of the gold rush, and it seems evident that the conditions which brought about the formation of gold placer deposits are of comparatively local development.

TOTAL PRODUCTION OF PLACER GOLD.

As already stated, the first production of placer gold from this district was made in 1913. During that year an amount of gold variously estimated as between $30,000 and $40,000 was recovered. In 1914 over 20 claims contributed to the production, and gold to the value of more than $250,000 was mined. It is therefore safe to say that the total production of the district up to and including the year 1914 was not far short of $300,000.

GOLD LODES.

For many years the existence of low-grade gold lode deposits in this region has been known. In 1906 a small stamp mill was erected at a gold lode on Jacksina Creek, a tributary of Nabesna River, and 60 tons of ore crushed in this mill is reported to have yielded $12 a ton of free gold. This marks the most serious effort to develop a gold lode property in the region, but other lodes have been staked, and varying amounts of excavation have been done on them. As a result of the gold placer stampede in 1902 from Dawson into the basin of Beaver Creek near the international boundary, a large number of gold lode claims were staked in that general district. These claims, situated on Beaver Creek near the boundary and on Eureka and Fourmile creeks, have already been described elsewhere,[1] and little development work has since been done on them. On Chathenda Creek at the mouth of Bonanza Creek a mineralized dike, known to contain some free gold, has been staked a number of times within the last eight years, but no serious attempts to prospect it have been made. The discovery of the rich placer deposits in 1913 naturally stimulated the search for the gold lodes from which the placers were derived, and a considerable number of gold lode claims have been staked in the district surrounding the placer mines. At the mouth of Bonanza Creek the mineralized area, which was first staked several years ago, was prospected by two tunnels each only a few feet long. For a distance of several hundred feet along Bonanza Creek the walls of the rock canyon are composed of an intrusive rock, from pink to gray in color, mottled with phenocrysts of darker minerals and containing abundant pyrite, the whole being oxidized on the surface to a rusty red color. There are in places bunches composed almost entirely of pyrite, and some small quartz veins cut the mass. The dike cuts Carboniferous lavas and pyroclastic rocks and apparently strikes N. 20° W. and dips about 75° N. The quartz veinlets are said to carry several ounces of gold to the ton, and the whole dike is reported to be auriferous. It is said that free gold can be panned from the oxidized and decayed surface portion of the out-

[1] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska: U. S. Geol. Survey Bull. 417, pp. 58-60, 1910.

crop. No assay reports of the gold content were available, and too little work has been done to determine the average gold tenor of the dike, the location of the ore shoots, or the extent of the auriferous portion of the dike.

In the canyon of Chathenda Creek, about halfway between the mouth of Dry Gulch and Bonanza Creek, there is a zone of mineralization in the Carboniferous rocks and the diorites which intrude them. This mineralized belt strikes approximately N. 65° W. and dips 78° SW., and a large group of claims has been staked upon it, extending from the canyon of Chathenda Creek up the mountain to the north. Two tunnels 10 and 15 feet long have been driven in a steep gully that joins the canyon, and several open cuts have been made. As shown by these disconnected openings, there is a belt reaching a width of 10 feet, of rusty mineralized country rock cut by some small quartz veins which carry sulphides and are stained by green copper carbonate. No sampling was done by the writer, but it is reported that assays taken from the quartz veins have shown a high gold content. Other claims, supposedly on the continuation of this mineralized zone, have been staked on both sides of upper Dry Gulch.

Some quartz claims have also been staked on Canyon Creek about three-fourths of a mile above its mouth, but no development work had been done there at the time of visit, in August, 1914.

CONDITIONS FAVORING THE FORMATION OF GOLD PLACERS.

Predictions as to the probable occurrence of commercially valuable deposits of gold in areas that have not yet been thoroughly prospected are not to be accepted with too much confidence, for of a dozen localities in which the conditions may seem to be alike, one may contain rich gold deposits and the others no ground sufficiently rich to mine. Nevertheless, prospecting in areas within which the geologic conditions are encouraging is likely to yield larger rewards than an equal amount of effort spent in unpromising areas. From a study of the Chisana placer district certain principles of broader application may be laid down. Among these are the following:

Placer gold should be sought only in those places where gold occurs in the bedrock, or where material derived from such gold-bearing bedrock has been brought by streams.

In those areas in which glacial erosion was severe the preglacial concentrations of placer gold are likely to have been removed and scattered. Locally portions of preglacial stream gravels may be preserved, but their discovery is likely to result only from thorough prospecting.

In such severely glaciated regions postglacial placers will be present only in those places in which postglacial erosion has been sufficient

to form new concentrations of gold, derived either from bedrock, from the scattered gold of preglacial placers, or from preglacial gold-bearing gravels which were not removed by ice erosion. In most places the postglacial erosion of bedrock has been too little to concentrate gold in sufficient quantities to form workable placers, although such a concentration seems to have taken place on Big Eldorado Creek.

In the Chisana district most of the stream placers have been formed by a concentration of gold derived originally from veins in the Carboniferous rocks near intrusive masses, somewhat concentrated in Tertiary gravel deposits, and later reconcentrated by streams before the last great period of glaciation. The glaciers scattered the stream concentrations of gold, but the postglacial streams have accomplished a later concentration into the deposits now being mined. This rather complicated chain of events may or may not have been duplicated in other parts of this general region, and therein lies the difficulty of stating the likelihood of other placer localities being discovered.

In a general way the conditions are promising. Between Nabesna River and the international boundary there are many places where granitic intrusive masses cut the Carboniferous sedimentary and volcanic rocks, and the borders of such intrusive masses deserve careful prospecting. If in such places bodies of unconsolidated Tertiary gravels are found, the streams draining the gravels should be prospected with care. Absence of severe glacial erosion would increase the probabilities for finding concentrations of placer gold.

COPPER.

Before the first white man entered the Chisana-White River region the Indians had brought out reports that great quantities of native copper occurred there, and instruments made of copper, as well as copper nuggets, said to have come from this region, were objects of barter between tribes of natives. As is usual with such reports the size reported for the metallic deposits increased with the distance from the area in which they were said to occur. The first authentic information published on the resources of this district was obtained in 1891, when Schwatka and Hayes[1] with one other white man made an exploratory trip from Fort Selkirk along the northern front of the St. Elias Mountains to the head of White River, across Russell Glacier, and thence southwestward to the mouth of Copper River. They failed to find the fabulously rich copper deposits reported by the natives but established the fact that placer copper occurs in the gravels of upper Kletsan Creek. Since their trip a considerable amount of prospecting for copper has been done in this

[1] Hayes, C. W., An expedition through the Yukon district: Nat. Geog. Mag., vol. 4, pp. 117-162, 1892.

region, and a number of copper lodes have been discovered. One large body of low-grade copper sulphide ore has been staked at Orange Hill, near the head of Nabesna River, a number of claims on deposits of native copper or copper sulphides are held between Nabesna and Chisana rivers, and a large number of claims, some of which have been patented, have been located in the White River basin. Many of these claims have been held for a number of years, but the remoteness of the region and its lack of transportation facilities make copper deposits of only prospective value, as mining under present conditions is out of the question. On some of the ground a good deal of development work has been done, but on most of the patented claims developments have ceased, and on the unpatented claims in general only the annual assessment work has been done.

With the exception of the discovery of a few new copper lodes, the value of which has not yet been demonstrated, and a moderate amount of development work on the ground already held, the conditions are much the same as in 1908, and the report[1] on the copper resources of the district published at that time is still sufficiently up to date, so that a republication of descriptions of the claims is unnecessary here. In the more complete report on this district, now in preparation, the individual copper lodes will be discussed more fully.

LIGNITE.

A formation consisting of conglomerates, sandstones, and shales, with some tuffaceous beds, all probably of Tertiary age, occurs at a few localities within this region and as shown by the structure and position of the beds was probably at one time much more widely distributed than at present. There is also a strong probability that other isolated patches of these same rocks occur within the area here discussed but have not been seen in the hasty reconnaissance work which has so far been done. These Tertiary rocks in places contain lignite, which occurs in thin carbonaceous layers and more rarely in beds of greater thickness.

On Coal Creek, a tributary of Rocker Creek, near the international boundary, some development work has been done on a lignite bed. A tunnel, said to be 30 feet long but now caved in, has been driven on a lignite cropping in a small gulch. The lignite strikes N. 50° E. and dips 68° NW. As exposed in the gulch outside the tunnel it occurs in two beds, one 3 feet and the other 1 foot thick, separated by a 1-foot clay parting. The lignite is clean and bright but rather friable and is said to burn readily and to be of sufficiently good grade to use in a forge for welding. A small amount has been mined and used by prospectors in this district, as this is the only known occur-

[1] Moffit, F. H., and Knopf, Adolph, Mineral resources of the Nabesna-White River district, Alaska: U. S. Geol. Survey Bull. 417, 1910.

rence of workable coal or lignite in a large region where the demand for such fuel is considerable. The lignite is interbedded with greenish sands and conglomerates, but the whole outcrop of this formation is of small area, being surrounded by intrusive rocks, and the amount of lignite at this place is probably not large.

At a point 1½ miles west of Ptarmigan Creek, 2 miles above its junction with Beaver Creek, there is a small area of Tertiary rocks reported to contain some lignite. The lignite is said to strike approximately north and dip steeply to the east and to be of rather poor quality.

The Tertiary conglomerates and sandstones crop out along the east side of the low pass between Chathenda Creek and Beaver Lake, but no lignite was seen there. Along Chathenda Creek below the mouth of Dry Gulch and in the basin of Rhyolite Creek there is an area of Tertiary sandstones and conglomerates, with agglomerates and tuffs, locally containing considerable carbonaceous material. Several prospect holes on Chathenda Creek show lignite on the dumps, although the lignite could not be seen in place. At the first forks of Rhyolite Creek above its mouth a bluff shows carbonaceous shale and sandstone with beds of lignite an inch or two in thickness, but no workable coal has been found.

Lignite is reported from the north side of the Nutzotin Range on a tributary of Beaver Creek. The locality is 7 miles west of the international boundary and about 1 mile south of the mountain front, and the outcrop is on a stream bluff. The area of Tertiary rocks at this place is not known, but the lignite is reported to form a bed about 8 feet thick, striking nearly east and dipping steeply to the south. It is said to be of fair grade and to burn readily.

MINING IN THE FAIRBANKS DISTRICT.

By HENRY M. EAKIN.

INTRODUCTION.

The writer devoted about 10 days in the later part of August, 1914, to the investigation of the recent mining developments in the Fairbanks district. This time was insufficient to visit all the operating mines, but by supplementing the observations made with information furnished by the operators fairly complete data were obtained on the principal developments.

In the summer of 1914 about 125 placer mines were operated in this district, employing some 1,200 men. Statistics of winter operations are far from being complete, but it is probable that not over 50 mines were worked. The value of the placer gold produced in 1914 is estimated at $2,500,000, compared with $3,300,000 in 1913. During the summer of 1914 the most productive creeks were Cleary and Pedro. Important operations continued also on Ester, Dome, Vault, Little Eldorado, Goldstream, Engineer, and Fairbanks creeks. The falling off in output is to be interpreted as indicating the exhaustion of the bonanza deposits and the nondevelopment of the extensive bodies of auriferous gravels of lower gold tenor.

There was a relatively greater decline of lode mining in 1914. Only four lode mines were operated long enough to be considered regularly productive. There were, however, eight or nine lode properties that made some gold output; in 1913 there were thirteen such properties.

PLACER MINING.

GENERAL ACTIVITIES.

The present placer-mining activities of the Fairbanks district are supported mainly by low-grade deposits, placers that yield $1 or less a square foot, which have lain in reserve on the productive creeks pending the exhaustion of the more profitable concentrations. During 1914 deep placers yielding as little as 40 cents a square foot were worked by drifting, and shallow deposits of still lower grade were worked in open cuts by mechanical methods.

Mining costs in terms of the volume of material handled have remained about stationary during the last several years, as the general advance in the price of fuel and supplies has been offset by an increasing economy in their use and an increasing efficiency of mining methods, equipment, and employees. The improvement of deep-mining methods has been made mainly in the details of operation and in the organization of forces. In shallow mining a great advance is being made by the increasing use of mechanical equipment. The output of the district in 1914 was derived more largely from mechanically operated shallow placers than in any preceding year. Winter mining has suffered a greater decline than summer operations, being more expensive and hence less adapted to the exploitation of the remaining low-grade placers.

REVIEW OF OPERATIONS BY CREEKS.

CLEARY CREEK.

Cleary Creek and the section of Chatanika Valley adjacent to its lower course continue to form the most productive placer-mining center of the district. Upstream from the margin of Chatanika Valley most of the richest part of the Cleary Creek pay streak has been worked out, but there is still considerable activity devoted to cleaning up the so-called "side pay" and the weaker parts of the pay streak that were rejected in earlier operations. From claim No. 11, above Discovery, to "No. 10 below" in this section of the valley 13 claims were active during the summer of 1914. They were worked by 13 plants that employed a total of 138 men. Claims "No. 11 above" and "No. 1 below" were worked in open cuts; the others were drifted.

The open-cut mine on "No. 1 below" is of special interest, as it marks the first installation of heavy mechanical equipment for this type of mining on Cleary Creek. The work of preparing the ground for open cutting has been in progress since 1912. A bedrock drain, 1,900 feet long, timbered and lagged throughout, was put in to keep the works free from water. In this work and in opening the first cut on the lower end of the claim a large amount of tailings of earlier operations was reworked, and the expense of the new undertaking was largely repaid by the gold thus recovered. The alluvium in this part of the valley is 16 to 22 feet in depth and consists of 6 to 12 feet of muck underlain by gravel. It is mostly thawed, but small spots are frozen and require thawing with steam points. The equipment includes an 80-horsepower Scotch marine high-pressure boiler, a large American triple-drum hoisting engine, two Bagley scrapers, and an electric-light plant. The first cut worked out in 1914 was 250 feet square. The muck was first removed by ground-sluicing and scrapg. The gravels were then worked by a rather complex but efficient

system. The scrapers delivered the material to a hopper at the side of the cut, which emptied into a 40 cubic-foot dump car. The dump car was hauled up a 200-foot incline, delivering the gravels to a dump box 82 feet long and 4 feet wide. The dump box and the sluice boxes, with the exception of two lengths of undercurrent, were floored with iron-shod wooden riffles. The system is reported to be very economical and capable of working low-grade ground profitably.

On Cleary Creek downstream from "No. 10 below" and on the adjacent section of the Chatanika Flats 16 plants operated during the summer of 1914 on 14 separate claims. About 200 men were employed. Much less activity was shown the previous winter. The alluvium in this area ranges from 34 to 140 feet in depth. It is perpetually frozen and consists chiefly of sands, gravels, and less worn rock materials. Locally, especially on the marginal slopes of Chatanika and Cleary valleys, the gravels are overlain by silts, in places of considerable depth. Elsewhere only a thin covering of muck is found.

The chief concentrations at this locality are the continuation of the Cleary Creek pay streak N. 65° W. for half a mile beyond the margin of the flats and the Chatanika pay streak, which runs S. 25° W. from the extremity of the Cleary streak. Other concentrations of less definite form parallel these west of Cleary Creek and south of the Chatanika pay streak. The information at hand indicates that the concentrations along the south side of Chatanika Valley appear to be on a series of benches that rise from the lowermost, 140 feet below the surface, to the uppermost, a quarter of a mile farther south, near the railroad and 56 feet below the surface. The surface rises southward, so that the progressive elevation of the benches is even more pronounced than the differences in depth indicate. Individual benches range from 10 to 30 feet in height. These benches are only partly revealed by the mine workings, but they appear to be cut in bedrock, and some of them, especially the higher ones, have steep fronts and flat tops. In some places the fronts are vertical; in others they are more or less gradual, and locally they are transected by narrow depressions that contain wash of a different sort than that overlying the adjacent terrace surface.

The distribution of gold on the benches has certain general characteristics. The higher gold content is found in zones near and parallel with the inner margins of the benches. The tenor of the bench placers is generally very moderate—40 to 80 cents a square foot—but in places there are local enrichments, especially in the vicinity of the transecting depressions mentioned above.

At a mine located just west of Chatanika village the shaft penetrated a rich placer at a depth of 56 feet, in gravel overlying a

stratum of unworn fragmental rock material that was long regarded as true bedrock. Later this stratum was penetrated and gravels beneath it were exposed. The shaft was then sunk to a depth of 75 feet and an equally rich concentration was discovered on the true bedrock surface. A short distance south of the shaft the lower concentration ends against a bedrock scarp, the front of a terrace, which rises to the level of the upper concentration and supports the southern part of it. The explanation of these facts must await much more exhaustive and detailed examination than has yet been attempted.

On Chatham Creek, tributary to Cleary Creek, two small plants worked a part of the summer. On Wolf Creek new discoveries were made during the summer that resulted in a marked stimulation of mining activity. Six claims were worked by 10 small outfits, employing about 50 men. The depth to bedrock on the upper part of the creek is slight, and open-cut methods are used. The ground deepens downstream to 30 feet on claims "No. 2 above" and "No. 3 above," and 60 feet on "No. 1 above," where drifting methods are required. The gold is not evenly distributed, and the gravels are said to range from those that are barely profitable to those yielding $4 a square foot.

ELDORADO CREEK.

Seven claims were active on Eldorado Creek, from "No. 5 above" to "No. 9 below." Seven plants, employing 85 men, were operated. Although none of the plants were large, at least four of them were worked in a very substantial manner and made a creditable production.

The later developments on Eldorado Creek, as on all the productive tributaries of Chatanika River, are on the flats of the Chatanika. The ground is 110 to 150 feet deep, and prospecting is necessarily slow and expensive in the absence of drilling operations. Preparations are under way for a renewal of prospecting on the Chatanika Flats in the attempt to trace the Eldorado pay streak beyond its present known extremity.

DOME CREEK.

Most of the mining on Dome Creek in 1914 was on the flats near its mouth. Two plants worked on the Shakespeare and two also on the Niggerhead association claims. "No. 14 below" and "No. 7 below" each had a single outfit operating. Only prospecting was done on the Dawdawn association. The seven outfits employed about 110 men. The ground deepens notably toward Chatanika River, and on the lower end of the Niggerhead association it is 170 feet to bedrock.

VAULT CREEK.

Seven plants, employing 118 men, worked six separate claims on Vault Creek during the summer. Four of these were among the largest in the district; the others were much smaller.

Two or three small plants worked successfully the preceding winter. Here also the chief activity is in the lower part of the valley and on the Chatanika Flats, where extensions of the pay streak have been more recently traced.

FAIRBANKS CREEK.

Summer operations on Fairbanks Creek were carried on from claim "No. 16 above" to "No. 15 below." Eighteen plants worked on 13 separate claims and their maximum force was about 180 men. The average number of employees for the season was considerably less. Only a little winter work was done.

The depth to bedrock on Fairbanks Creek ranges from a few feet near its head to 120 feet on "No. 15 below." In the headward section the mines are open cut; farther downstream drifting methods are employed. The open-cut mines are operated largely by manual methods, but a few are equipped with steam scrapers.

The only dredge in the district is that of the Alaska Exploration Co. on claim "No. 8 above," Fairbanks Creek. It has a close-connected line of 3½-cubic-foot buckets and a 40-foot ladder. It is run by steam power, and wood is used for fuel. The ground is 10 to 12 feet in depth and is thawed. Mechanical troubles have prevented continuous operation of the dredge, and the lack of thorough prospecting before the earlier operations made necessary a great deal of dead work that otherwise might have been avoided. This defect in the plan of operation is being remedied by extensive drilling on the ground toward which the dredge is working.

FISH CREEK.

A little mining was done on Fish Creek on claims "No. 1 above" and "No. 2 above." Other operations in the Fish Creek basin were those on First Chance Creek, Monte Cristo Pup, and Pearl Creek. These operations altogether included half a dozen outfits working separate claims and employing about 20 men.

TWIN CREEK.

A single small ground-sluicing outfit worked on Twin Creek near its mouth a part of the summer. An attempt was made early in the season to operate on a larger scale farther upstream, but it was abandoned after a short trial.

PEDRO CREEK.

All the claims on Pedro Creek from "No. 1 below" to "No. 10 below," except Nos. 7 and 9, were worked during the summer of 1914. Of the eleven plants operating, seven were equipped with steam scrapers and worked in open cuts. The other four plants drifted and used steam hoists. About 130 men were employed. During the preceding winter only two or three small drifting outfits were active. Open-cut mining was done in ground that ranged from 10 to 20 feet in depth. Most of the drift mines were in deeper ground nearer the margins of the valley.

The Pedro Creek open-cut operations probably represent the highest efficiency in handling yardage yet developed in the district. Their economy is strikingly apparent when it is remembered that the whole depth of alluvium is removed mechanically, and that the gold tenor, considered areally, is only moderate.

Some of the plants worked out of their ground during the summer. Others have from one to three seasons' work ahead before the available ground will become exhausted.

GOLDSTREAM CREEK.

Thirteen separate claims were worked on Goldstream Creek for longer or shorter periods during the summer of 1914. Nineteen different outfits operated with a maximum force of about 160 men. A little work was done by several small plants during the winter.

A small plant operated both winter and summer on First Chance Creek, and another on Gilmore Creek, both tributaries of Goldstream Creek. Also three plants employing 50 men worked on Engineer Creek during the summer and a single small plant during the winter.

From claim "No. 3 below" to "No. 6 below," Goldstream, open-cut methods and scraper equipment were in use on three claims. Farther downstream and on the tributaries mentioned the ground is deeper and is drifted.

ESTER CREEK.

Six plants, employing about 70 men, worked on Ester Creek in the summer of 1914, and seven plants, employing 50 men, in the preceding winter. The principal summer work was on Discovery claim and "No. 3 above." The center of winter activity was Gold Hill bench, near the mouth of Ester Creek, where five small outfits were employed.

Although the richer placers have long been exhausted at this locality, there are apparently considerable areas of "side pay" bordering

the old workings that are capable of supporting profitable mining with the exercise of rigid economy. Unexpected returns, it is said, were obtained from some of the new workings, on claims that were considered entirely worked out years ago.

EVA CREEK.

Prospecting only was done on Eva Creek during the year. Drill work on the Minnesota association is said to show good concentrations, but the ground is thawed, so that it can not be worked with present equipment.

A working shaft was sunk on the upper end of the Happy Home association on the strength of alleged determinations made with a divining rod. Without any other evidence of the existence of placers beneath the surface, this laborious and expensive piece of work was undertaken with complete confidence in its successful issue. It is interesting to note the persistence of this archaic idea, which, if at all trustworthy, must long ago have been universally adopted as a substitute for all other modes of prospecting.

READY BULLION CREEK.

Successful operations were carried on by a large plant in summer and a smaller one in winter on the Mihalcik bench on Ready Bullion Creek. The only other activity on the creek was desultory prospecting for "side pay" on some of the worked-out claims.

OTHER STREAMS.

Small plants were operated for a part of the season, one on St. Patricks Creek and one on Happy Creek, which are tributary to Cripple Creek. Only a little prospecting work is reported in the Smallwood Creek basin and little is known of the results obtained.

A little activity is reported on two or three claims on Chena River. Only a few persons worked in this section, and they produced only a few hundred dollars.

The Tenderfoot district includes a small area in the vicinity of Richardson post office and is drained by several small northerly tributaries of Tanana River. The productive creeks in 1914 were Tenderfoot Creek and Democrat Pup, a tributary of Banner Creek. On Tenderfoot Creek claims Nos. 4, 5, 6, and 16 were worked by three plants, employing about 55 men. The ground is 90 to 170 feet deep and is drifted. On Democrat Pup two outfits operated during the summer. The ground is shallow and is worked in open cuts by ground sluicing together with manual methods.

LODE MINING.

CAUSE OF THE DECLINE.

Although the decline in lode mining noted above is in part due to the failure of some of the properties to justify further development work, it is more largely the result of retrenchment on the part of operators who are unwilling to invest further in mine development or to exploit their proved reserves under the present cost of operating, and who hope for larger returns on their investments and larger operating profits when the projected Government railroad shall have given a new and lower schedule of costs. Present costs are not only prohibitive for mines whose ores yield $20 or less to the ton, but they burden the richer mines as well by limiting operations to only the richer parts of lodes and curtailing the profits of their exploitation. Any reduction in costs would not only increase the net revenues from such ores as are now mined, but would also permit a marked enhancement in the value of lode properties. Because of this outlook some of the largest operators in 1914 were considering the advisability of shutting down until the railroad is completed.

MINES WITH REDUCTION PLANTS.

The most important lode operations in the district in 1914 were those of the Rhoads-Hall mine, on Bedrock Creek; of the Soo Mining Co., near the head of Dome Creek; and of Crites & Feldman, on Moose Creek. Only these mines operated their own mills for much of the year.

The Rhoads-Hall mine was worked throughout the year, and the mill operated about 350 days. The mine furnished a practically continuous supply of ore, so that little or no shortage was felt. New ore was blocked out at about the same rate that the older workings were depleted. About 3,000 feet of development work was done, 1,800 feet in ore and 1,200 feet in waste. Of this work 2,000 feet was comprised in drifts, chiefly on the 70-foot and 100-foot levels. Connections driven between levels aggregated about 1,000 feet. About 50,000 feet of vein matter was stoped out. An average of about 23 men were employed, 18 in the mine, 3 in the mill, and the others at the mess.

The Soo Mining Co. was engaged during the year chiefly in mine development and prospecting. Six to ten men were employed. The mill was run at intervals as ore was provided by the development work.

The Crites & Feldman property on Moose Creek showed a marked development during the year. Five men were employed in the mine extending tunnels and opening out for stoping. The creek-level

tunnel was extended to a depth of 450 feet, and the main adit, 90 feet higher, to 550 feet, both in ore their whole extent. A little stoping was also done. The 4-stamp Hendy mill that was formerly located on Chatham Creek was moved to a new site on Moose Creek below the mine during the summer and began crushing about September 1.

MINES WITHOUT REDUCTION PLANTS.

A number of mines not equipped with reduction plants produced more or less ore, which was treated at the mill-equipped mines or by custom mills, of which there are several in the district. Three mines of this character operated in the Fairbanks Creek section, two in the Cleary Creek basin, and two at the head of St. Patricks Creek.

The active mines in the Fairbanks Creek section were on the Mayflower, Pioneer, and Roy Lode claims. The first two claims had been developed to some extent prior to 1914. The development of the Roy Lode claim followed the discovery of rich ore in July, 1914. A small test shipment was made late in the summer, and satisfactory returns were reported. In all about 40 tons of ore from the three mines was milled, from which $3,000, or $75 a ton, was recovered.

In the Cleary Creek basin the Tanana Quartz & Hydraulic Mining Co.'s holding on upper Bedrock Creek and the Homestake mine on Wolf Creek were worked in the same small way as in previous years. The work on the former property is said to aim chiefly at mine development, and the returns are derived from shipments made to test the various parts of the lode.

The Homestake mine is operated under lease. The ores produced are chiefly from a rich vein that averages only 5 inches in width. About 35 tons of ore milled from the two properties is said to have yielded well over $100 a ton.

At the head of St. Patricks Creek the Mohawk and Fairchance properties were active. Over 50 tons of ore was produced, ranging in tenor from $18 to $50 a ton.

PROSPECTING.

A number of properties in the district are being actively prospected and developed, but are making no actual production of gold, as the ores produced are not milled. These operations vary widely in results attained, but altogether comprise a very encouraging aspect of the industry. Although some of the claims under investigation will probably be added to the long list of valueless properties, there are others that promise to become highly productive mines.

In the Fairbanks Creek section several properties are being prospected in a small way. The Nars-Anderson-Gibbs holdings are being slowly developed by Mr. Gibbs, who has purchased the interests of the other interested parties. A resumption of work on the Mizpah

claim was planned for the fall of 1914. The Ohio group, opposite placer claims "No. 13 above" and "No. 14 above," was prospected by two partners, who have sunk an 80-foot shaft on a vein that averages 2 to 2½ feet in width. They have 20 tons of selected ore on the dump. The American Eagle claim, farther upstream, has recently been released from litigation and prospecting under lease has begun.

In the Cleary Creek basin the Rexall mine has been leased by new operators and an early resumption of operations is planned. In the Chatham Creek valley the Chatham and Pioneer properties are idle, but an attempt to finance further development work in under way. On Willow Creek the Newsboy mine is idle, but it is planned to continue development and mining when costs reach a sufficiently low point to make it profitable. On the Emma claim, at the head of Willow Creek, a little work was done in 1914.

In the valley of Twin Creek the Rainbow mine is closed, but it has been recently let under a new lease and large-scale operations are contemplated in the near future. The Moonshine and Sunshine claims near by were prospected during the winter of 1913–14.

In the Ester district the most important prospecting work under way is that of Tyndall & Finn on the Bondholder and Yellow Jacket claims, near the head of St. Patricks Creek. The Bondholder discovery was made in 1912. In 1913 a little development work, chiefly surface open cuts, was done, and in 1914 the work was continued by a force of three to five men. Four inclined shafts, 20 to 140 feet deep, were sunk along the footwall of the main Bondholder lode. The shafts are 7 feet wide across the strike of the lode, and every 20 feet a test drill hole was driven into the hanging wall to a depth of 5 feet. At a depth of 55 feet in the main shaft a 50-foot drift was driven to the southwest on the strike of the lode. The ore was tested by crushing and panning, and samples that made a good showing in the pan were considered workable. By this test the main lode is said to have a determined minable width of 12 feet.

In June, 1914, an adit was started from the creek level on the Yellow Jacket claim, 250 feet lower than the collar of the main Bondholder shaft. In December it had been driven 175 feet, and the operators intended to drive it about 325 feet farther to undercut the Bondholder lode, and proposed to complete it by June, 1915. Three distinct lodes of smaller size on the Yellow Jacket will also be cut. The tunnel is 6½ feet high, has 6-foot sills and 4-foot caps, and is laid with an 18-inch gage track of 8-pound rails. Steel cars of 10 cubic feet capacity are in use. Tyndall & Finn are also developing the Mohawk claim and report the discovery of a 6-foot lode during the fall of 1914, on which they have sunk three shafts to a depth of 26

MINING IN THE HOT SPRINGS DISTRICT.

By HENRY M. EAKIN.

GENERAL ACTIVITIES.

The Hot Springs district had a highly prosperous season in 1914. The production is estimated at $750,000, compared with $400,000 in 1913. The Sullivan Valley continued to be the most productive center. Two areas of extremely rich placer ground have been located here, one in 1912 and the other in 1913. Both areas were worked on a large scale in 1914 and contributed the larger part of the production of the district.

Other sections of the district also showed a marked improvement over the previous year. American Creek, where gold was discovered in 1911, was better equipped with machinery and made a very creditable showing. In the Pioneer Creek basin new deposits favorably situated for hydraulic mining were discovered. Many older claims throughout the district were also operated with fair success.

THE PLACERS.

The placers of the Hot Springs district are widely divergent in character, form, and manner of distribution. The types disclosed by operations include ordinary pay streaks, bench deposits, stream reconcentrations from bench deposits, and irregularly distributed discontinuous bodies that do not enter into the familiar classification of placers.

Placers of the ordinary pay-streak type occur only in relatively narrow and high-walled valleys, notably in those of American and Eureka creeks.

Bench deposits occur along the sides of valleys or skirt around the points of interstream features from one valley to another. They are as a rule essentially horizontal and some of them extend for long distances. Low-grade bench deposits of this type extend westward from Eureka Creek along the north side of the Baker Creek basin across the valleys of several small streams. A less extensive bench deposit skirts around the point of a ridge between Quartz Creek and its chief western tributary. A series of benches, the largest of which is What Cheer Bar, are developed on the north side of Pioneer

Creek valley. These extend far up toward the head of the valley and are crossed by a number of small northern tributaries of Pioneer Creek.

Reconcentrations from bench deposits are found in the northern tributaries of Pioneer Creek and in the streams that cross the extensive bench deposit west of Eureka Creek.

The placers of unusual type referred to above are fittingly described as "spots" by the local operators. The simplest forms are rudely elliptical in outline and have a relatively rich central area, away from which the gold tenor and the size of particles decrease out to the margin of profitable ground. Such placer spots are developed locally on the surface of bedrock terraces. Some of them appear upon a single terrace. More complex forms are in places developed upon several closely spaced terraces, and it is not uncommon to find a great variation in the elevation of bedrock in a single mine, the surface being everywhere sensibly flat except in the terrace scarps. Many of the central areas are of bonanza richness. In one mine $200,000 is said to have been produced almost entirely from a space of 5,000 square feet. On higher terraces at the same locality several other small areas of but slightly lower tenor were mined. Still other mines have shown small areas containing $10 to $30 in each square foot. The minable area of individual spots ranges from a few thousand square feet to a few acres. The larger areas are usually more complex in form and include two or more terraces. In such areas the distribution of gold is also complex, a richer area usually appearing on each terrace. The placer spots are known to occur only in the Sullivan Creek basin. They have been developed on lower Cache Creek and in the Sullivan Creek valley a quarter of a mile above Tofty and at five localities from half a mile to 5 miles below Tofty.

The alluvium developed in these mines is 50 to 170 feet deep. Still greater depths are known to occur in the basin. The material is mostly light-colored stratified silt, but in places its upper part is dark colored and contains vegetable material and ground ice. The silts are generally underlain by gravels or less worn fragmental material. This material ranges in thickness from a few feet to 35 feet, as shown in the mine workings.

Large, well-worn bowlders, measuring as much as 7 or 8 feet in diameter, have been found in the gravel deposits, on their surface beneath the silts, and in the silts above the top of the gravels. That they were not produced or transported in the same manner as the other deposits is clear. Some of them are apparently not of local origin.

The Sullivan Creek placers contain tin ore as well as gold. The character of concentration is the same, and the two minerals are prob-

ably closely allied as to their bedrock source. Hematite and pyrite are also associated with them in some of the placers.

CONDITIONS THAT GOVERN MINING PROGRESS.

The variety and unusual types of placer deposits and the general lack of familiar topographic guidance has made prospecting unusually hazardous and expensive in the Hot Springs district. In the absence of large continuous deposits the fortunes of mining have been closely allied with those of prospecting, and the industry has progressed in an erratic and uncertain manner. Very little capital not produced within the district has been used, and the earnings of earlier operations have been largely reinvested in the attempted development of new deposits. Disappointments have been numerous, and the combination of confidence and funds has remained with but a few operators.

The production in 1914 exceeds that of any other year in the history of the district except 1911, when the output was considerably greater. The large production in 1914 is due chiefly to comparatively recent discoveries in the Sullivan Creek valley and on a tributary of Pioneer Creek in the older section of the district. The Pioneer Creek discovery was made wholly by accident and in a situation not considered favorable for prospecting by local operators. The other two discoveries are the result of one of the greatest financial ventures ever made in prospecting for placer ground in Alaska. A small fortune, the entire net production of one of the richest mines in the history of the district, was spent to the last dollar in drilling the deep ground of Sullivan Valley. Half the amount had been spent when the first strike was made in 1912 on Miller Gulch. Control of the ground was lost to the discoverer, and drilling was resumed. A year later the placer on Hokeley Gulch was struck, and the confidence of the operator was justified at the very time his capital was exhausted.

It must be confessed that the drilling operations of this venture were more or less haphazard and that their successful issue was due more to the large capital employed and to good fortune than to a sound hypothesis regarding the distribution of concentrations or any systematic scheme for carrying on the search. It is not at all certain that another similar venture following the same plan and method would be equally successful. It seems possible, however, that the hazard and expense of prospecting could be notably reduced by taking the probable origin of the placers more into account and by making a better use of the data furnished by mining operations and drilling regarding the surface features of bedrock beneath the alluvium and the relation of concentrations to such features.

OPERATIONS IN 1914.

The Hot Springs district includes three rather distinct placer areas—the Baker Creek area, to the east; the Sullivan Creek basin, located centrally; and the American Creek area, to the west, near the junction of Yukon and Tanana rivers. These sections of the district will be taken up in order.

BAKER CREEK TRIBUTARIES.

Operations were carried on in the Baker Creek section of the district on Thanksgiving, Gold Run, Eureka, and Pioneer creeks, whose names have been familiar in the annals of placer mining for more than a decade. For the most part the present operations are conducted on a small scale and represent the lag end of the industry, as the rich placers have long been exhausted and only a few known spots rich enough to support mining remain. The deposits on Seattle Jr. Creek, a tributary of Pioneer Creek, are exceptional in being recently discovered and of relatively high grade. In addition to the creek placers two areas of bench placers were worked, each by a small outfit, one between Thanksgiving Creek and Gold Run and the other between Gold Run and Eureka Creek.

Two plants operated on Thanksgiving Creek and one on Gold Run by the familiar method of groundsluicing and shoveling in. On Eureka Creek a steam-scraper plant operated at a point half a mile above the mouth of Pioneer Creek. On the northern tributaries of Pioneer Creek three plants operated and a fourth was engaged in dead work preparatory to operating in 1915. Two of the active plants were small groundsluicing outfits. The third operated the newly discovered ground on Seattle Jr. Creek, using hydraulic equipment.

In all ten plants worked in this part of the district and employed a total of 60 men.

SULLIVAN CREEK BASIN.

Large scale operations were carried on throughout the summer on Hokeley and Miller gulches. Work was resumed on the Midnight Sun claim late in the summer with the intention of continuing through the winter. A little prospecting and mining was done on lower Cache Creek and on the high bench west of Quartz Creek.

HOKELEY GULCH.

Hokeley Gulch heads about 5 miles southwest of Tofty in a swampy flat and flows southwestward for 1½ miles into Woodchopper Creek, a tributary of Sullivan Creek. A large area of rich placer ground

was located on the Wild Goose claim, about a quarter of a mile east of the head of the stream, by Adolph Bock in March, 1913. Later in the same year the ground was explored by a shaft and drifts, and preparations were made for extensive operations the following season. During 1914 an average of over 50 men were employed. Day and night shifts were used throughout the season, and part of the time dirt was hoisted from two separate shafts by the same power plant. Power was generated by three 50-horsepower boilers using cordwood fuel. Water for the boilers and to replenish the sump from which the sluice boxes were supplied was pumped from a small lake half a mile south of the mine.

The shafts penetrate 130 feet to bedrock, most of the way through light-colored stratified and frozen silt. A stratum of gravel 6 to 8 feet thick lies on bedrock beneath the silts. The gold is well concentrated on bedrock and in the lowermost gravels. It is well worn and of fine, even texture, indicating considerable transportation and assortment prior to its deposition in the present placers.

Although the deposit has not been fully outlined, margins have been located which indicate that it is not part of a continuous pay streak but is irregularly terminated in all directions. The gravels vary in gold content from place to place, ranging from those that are barely workable near the margins to some of very high tenor, about the central shaft. There are considerable areas that yield $4 to $6 or more to the square foot, and the entire minable area is thought to extend over several acres. Stream tin occurs with the gold, but no special attempt was made to recover it.

There is considerable difference in depth between the two shafts, though they are only a few score feet apart. To the southeastward bedrock drops off to still lower levels.

MILLER GULCH.

High-grade placers were discovered by drilling on the United States Association claim, in lower Miller Gulch, in 1912. Later discoveries have developed areas of placer ground at intervals for about a mile northwestward toward the head of the gulch. The surface of the claim has a gentle eastward slope. However, depths to bedrock range from 85 to 120 feet within a horizontal distance of 500 feet, the difference in elevation of the bedrock being accounted for in bold scarps that stand between adjacent level-surfaced features. These features persist for a considerable distance toward the head of the gulch. Above the United States Association claim the first placer area is 65 feet below the surface and the next one 45 feet. The uppermost placers are at still less depth and are apparently of the ordinary pay-streak type.

Three mines were worked on Miller Gulch in 1914, one of which operated three plants most of the time. On an average a total of 112 men were employed.

Rich concentrations of tin occur with the gold, and some of the plants were equipped to recover all that they mined. About 30 tons of concentrates are reported as saved by one mine.

THE MIDNIGHT SUN CLAIM.

The Midnight Sun claim is about a quarter of a mile northwest of Tofty and 500 feet east of Sullivan Creek. The ground is 50 to 65 feet deep and for the most part is perpetually frozen. The pay streak lies on and near the bedrock surface, which has the form of a well-preserved series of low terraces both here and on the Abe Lincoln claim adjacent to the southeast.

Under the first management the Midnight Sun mine was developed in a very efficient manner and a large production was made. Later the control passed to other hands, and after a short season serious caving occurred and the mine was flooded by surface waters and by ground water from a body of thawed gravel that the workings penetrated. The mine was closed and laid idle until the summer of 1914, when the original management regained control. It was planned to reopen the mine by sinking a new shaft in barren frozen ground near the placer area and driving tunnels to tap the known bodies of pay gravel adjacent to the old workings. This work was to be done mainly in winter, in order to avoid the surface waters that enter the old workings through a caved-in sump. Pumping apparatus was to be installed to handle the ground water.

CACHE CREEK.

A great deal of mining has been done on Cache Creek, mostly on small areas of rich ground that have supported but short-lived mines. Productive years have alternated with nonproductive, when the efforts of operators were directed entirely to the search for new placer areas. This was the situation during most of 1914, but toward the end of the season operations were begun on a newly discovered area of low-grade ground.

QUARTZ CREEK.

The deposit in the Quartz Creek basin known as Homestake Bar is situated on a gentle slope about a quarter of a mile west of the stream and at an elevation 60 to 75 feet higher. It is the shallowest placer of the Sullivan Creek basin, consisting of only 3 to 4 feet of gravel and coarse fragmental materials overlain by 3 feet of yellow silt. The deposit continues horizontally around the point of the low

ridge that separates Quartz Creek from its chief western tributary for about a quarter of a mile, but it is at present workable as placer ground for only a part of this distance.

Small-scale operations carried on by manual methods have been in progress on Homestake Bar since 1910, and in 1914 four men were so engaged during the summer.

AMERICAN CREEK.

American Creek is about 15 miles west of Tofty. The headward part of its valley for about 2 miles is in the high bedrock area that borders Sullivan Creek farther east. This part of the valley is deep, steep-sided, and relatively narrow. Beyond the margin of the bedrock area the stream flows for about 3 miles over a broad flat that is continuous with the floor of the lower Sullivan Creek basin and enters the east side of Fish Lake.

The grade of American Creek in the reach where prospecting has been done is 70 to 85 feet to the mile. In the upper narrow part of the valley the alluvium ranges between 12 and 18 feet in depth. Out on the flats beyond the margin of the hills the depths increase rapidly, indicating that the bedrock surface has here a much steeper slope than in the headward part of the valley.

The placers of American Creek, so far as known, occur within the more constricted part of the valley. They have the form of a well-defined continuous pay streak, 40 to 100 feet wide, within which the gold content ranges from that of barely workable gravels up to $1.35 a square foot.

Three steam hoists and two hand-windlass outfits worked the five productive claims of the creek in 1914. A small outfit was also engaged in prospecting in deeper ground near the margin of the flats. Thirty men in all were employed in this part of the district.

MINERAL RESOURCES OF THE LAKE CLARK-IDITAROD REGION.

By PHILIP S. SMITH.

INTRODUCTION.

The area described in this report has for convenience been called the Lake Clark-Iditarod region. It is roughly quadrilateral and is bounded on the southeast by Lake Clark and on the northwest by the town of Iditarod—that is, it extends from latitude 60° to 62° 30′ N. and from longitude 154° to 158° W. Plate X (p. 270) shows the relation of this area to the southwestern part of Alaska.

Different parts of this region have been examined with very different degrees of thoroughness. Thus the region around Iditarod was examined by Maddren in 1910 and by Eakin in 1912, and the region contiguous to Lake Clark by Martin and Katz in 1908, and reports by these different geologists have been prepared and published.[1] To the east the early surveys of Spurr[2] and Brooks[3] have afforded the most authoritative statements as to the geology and geography of the country. To the west the main source of information has been the report of Spurr, although in 1914 Maddren visited the region and is preparing a report of his observations.

The area lying between the settlement of Iditarod on the northwest and Lake Clark on the southeast is divisible into three parts, the section near Iditarod being the best known and most exploited, the part near Lake Clark being the next best known, and the part between these two places being practically unmapped except for Spurr's survey of Kuskokwim River, which transects the unexplored portion from east to west.

All the available information derived from different sources has been considered in preparing this report, but many of the observations on the mineral resources were made by the writer while

[1] Maddren, A. G., Gold placer mining developments in the Innoko-Iditarod region: U. S. Geol. Survey Bull. 480, pp. 236–270, 1911. Martin, G. C., and Katz, F. J., A geologic reconnaissance of the Iliamna region, Alaska: U. S. Geol. Survey Bull. 485, 138 pp., 1912. Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, 45 pp., 1914.

[2] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 43–268, 1900.

[3] Brooks, A. H., The Mount McKinley region, Alaska: U. S. Geol. Survey Prof. Paper 70, 234 pp., 1911.

attached to a Geological Survey party that traversed the region in 1914. This party, consisting of 7 men, was in charge of R. H. Sargent, topographer, and its supplies and equipment were transported by a pack train of 20 horses. The party left Iliamna Bay June 7 and reached Iditarod September 9. As a result of this trip about 5,000 square miles of previously unsurveyed country was mapped, the positions of certain previously known features were determined with more precision, data were obtained concerning the geologic and physiographic character and history of the region, and scattered notes were made about the flora, fauna, climate, and population. In the present report, however, only the facts bearing on the mineral resources of the region are given in detail; the other facts will be set forth more completely in another publication which is now in preparation.

To the members of the Survey who have served with the writer in the field and in the office hearty acknowledgments are due. Special thanks are given to R. H. Sargent, in charge of the field expedition, for his unfailing assistance in furthering the geologic investigations. Obligation is acknowledged to the field members of the expedition, E. C. Carlberg, C. A. Anderson, J. D. Nelson, Olaf Holt, and Earl Kelso. In the microscopic examination of the rock specimens collected by this expedition the writer was aided by J. B. Mertie.

The few white people living in the region all courteously assisted the expedition with the help and information they possessed. This was especially true of Commissioner Thomas W. Hanmore and Messrs. W. S. Foss and A. Ruel, at Iliamna village; of Messrs. Hans Sieversen and Frank Brown, at Newhalen and Sixmile Lake; of Messrs. Fred Bishop and E. W. Parks, near Sleitmut, on the Kuskokwim; of Capt. Jung and crew of the steamboat used in crossing the Kuskokwim; and of the residents of Iditarod and the miners and prospectors on Flat and Otter creeks.

The natives employed at Iliamna Lake, at Sixmile Lake, and on the Kuskokwim worked faithfully and efficiently to promote the objects of the expedition and deserve appreciative thanks. The services rendered by Sakaren, chief of the Nondalton natives, and of Wasca, one of the Kuskokwim natives living near the mouth of the Holitna, are acknowledged with especial gratitude.

GEOGRAPHY.

The northeastward-trending highland of the Pacific mountain system is one of the most prominent features of southwestern Alaska. In the Lake Clark-Iditarod region the main axis of the Alaska Range does not extend beyond the north end of Lake Clark, and the axis of the Chigmit Mountain lies to the east of both Lake Clark and Iliamna

Lake. The region here described therefore lies west of this great physiographic province and is part of the central plateau region. In few places is the mountain province separated from the plateau province by a sharply defined line, but the two usually merge into each other through a foothill belt. Although not a high mountain mass the plateau province is characterized by greatly deformed rocks ranging in age from Paleozoic to Tertiary.

Many of the large streams head in the highland area and flow thence across the general structural trend until, at a greater or less distance from the high mountains, they collect to form the major rivers whose courses are more or less parallel with the axes of the mountain system. Certain other streams originate in the plateau province and swell the master streams of the region, but most of these streams are shorter and of smaller volume.

By far the most important stream of the region is the Kuskokwim, which receives several tributaries from the east that rise in the high mountains as well as many other side streams that head within the plateau province. The three other major basins, from south to north, are the basin drained by Lake Clark, Iliamna Lake, and Kvichak River, the Mulchatna-Nushagak river basin, and the Iditarod River basin, the water of which is ultimately tributary to the Yukon. The first two of these discharge into Bristol Bay and the third into Norton Sound.

These four main basins form definite, easily delimited areas that serve well for purposes of description, but they are not geomorphologic units, for each individual basin shows several physiographic subprovinces, and several of the subprovinces extend uninterruptedly from one basin to another. Thus each of the basins is made up of highlands and lowlands, the boundaries of some of which are not coincident with the boundaries of the different drainage basins.

Taken as a whole, the Lake Clark-Iditarod region is an area of moderate relief with scattered, irregularly distributed, rather small highland areas separated from one another by lowlands, some of which are of large size. The relative proportion of highland to lowland is probably approximately 2 to 1. East of the Lake Clark-Iditarod region this ratio probably increases, but toward the west it decreases, so that in places it may even be reversed. Here and there the main streams lie near the surface of the broad, widely open lowlands, but in other places they are hemmed in by steep slopes that rise to the rolling uplands through which they flow.

Trees and bushes are common in the valley bottoms, but on the slopes they decrease in size and number until at 500 to 1,000 feet above the streams they are absent and only grasses and mosses grow or their places are taken by bare rocky ledges. The larger trees are dominantly spruce. Some of the trees are more than 18 inches in

diameter, but their average diameter in the better-timbered areas is probably about 1 foot. Feed for stock is not plentiful in the poorly drained areas; in fact, it is so scanty that it must be searched for. In the higher parts of the region it is most abundant near the upper limit of the trees.

Game is rather scarce throughout the region, though hard-beaten trails indicate that in the past many of the larger animals were abundant. Probably not more than a hundred people live in the region outside of the few mining camps. The bare, undistinctive hills, the low brown flats with lakes and marshes, and the small number of people or animals make the region as a whole appear desolate and unprepossessing.

GEOLOGY.

Between the west coast of Cook Inlet and Lake Clark rocks of different ages and complex structure have been intruded by a batholithic mass of granitic rocks of Mesozoic age. Northwest of Lake Clark the hard rocks are composed dominantly of Mesozoic sediments, which are considerably deformed and have been intruded at different times by igneous rocks that differ in composition and age. Some Paleozoic rocks also are exposed here and there in the area. Although all these rocks are exposed at different places in the region, the widespread unconsolidated water-laid deposits which mantle the lowlands and, as it were, submerge the lower hill slopes constitute the dominant geologic formation. The accompanying geologic map (Pl. X) shows the main stratigraphic units, but owing to its small scale the details have been omitted. For instance, the representation of the unconsolidated deposits has been generalized so much that the map does not show that practically every part of the region south of the Kuskokwim that was visited is more or less covered with these deposits. Even the hills that rise to elevations of 3,000 feet or more above the sea have in many places pebbles and waterworn gravels on their summits.

The Paleozoic rocks that were recognized by the expedition of 1914 consist entirely of limestones. These rocks are exposed south of Kuskokwim River and form a series of bare white hills, which make prominent landmarks. Similar limestones are reported to occur on the Holitna and on the Kuskokwim near McGrath. Other Paleozoic rocks north and west of Iditarod, mostly slates, cherts, and greenstones, have been reported.

The Mesozoic rocks are dominantly shales and sandstones, but in places, especially near the base of the section represented in this area, there is a great thickness of conglomerate. Fossils of Cretaceous age have been found in some of these rocks, and others of Jurassic age have been found in adjacent areas, in rocks correlated with cer-

tain rocks of the Lake Clark-Iditarod region. All the rocks have been folded, faulted, and considerably eroded.

Igneous rocks, both intrusive and effusive, are associated with or cut the Mesozoic sediments. The intrusive rocks are mainly of granitic composition and probably represent more than one epoch of intrusion. Thus the granitic batholith east of Lake Clark is regarded as of pre-Cretaceous age, whereas acidic intrusives cut the Cretaceous rocks near Iditarod and at many places in the Kuskokwim basin. The intrusive rocks, so far as seen, occupy few large areas in the Lake Clark-Iditarod region. Instead they occur usually in rather small stocks, or even more commonly in dikes.

The largest area of effusive igneous rocks is in the vicinity of Lake Clark, where porphyritic rocks, in general of andesitic composition and probably of Lower Jurassic age, are exposed. In this same region other lavas of Tertiary or Recent age, which still retain a glassy aspect and surface flow structure, overlie the older rocks. Tuffs and agglomerates are associated with lavas of both these types. They range in color from dark brown or nearly black to cream-white. Some of them are interlaminated with the Mesozoic sediments, and probably parts of these sedimentary rocks are composed of volcanic tuff which has been but slightly worked over by water.

The unconsolidated deposits of nonresidual material are composed mainly of fluviatile, glacial, and glaciofluviatile sands, gravels, and silts. The glaciofluviatile material mantles the whole region so deeply that it obscures in large measure the records of the early part of Quaternary time. A definite limit between the glacial and glaciofluviatile deposits can not everywhere be drawn, as the two types show all phases of intergradation. Some distinct moraines are recognizable at a number of places, but most of the moraines have been obliterated by the outwash deposits from a later stage in the retreat of the now vanished glaciers. The glaciofluviatile deposits merge, on the other hand, into typical stream deposits. The modern streams in the main are reworking the older deposits and in relatively few places are eroding only the hard rock of their valleys. The deposits, therefore, contain a large amount of material foreign to the drainage of the stream in which they occur.

The geologic structure of the region trends, in general, northeast, but this broad structure is complicated by minor deformations, and the unconsolidated deposits, none of which have been affected by it, in large measure obscure this trend. The general structure between Lake Clark and the Paleozoic limestones of the Stony River basin appears to be that of a somewhat faulted and deformed synclinorium, the limestones appearing to be on the southern flank of the accompanying anticlinorium. Whether another syncline succeeds the limestones on the northwest has not been determined. The abruptness

with which the topography breaks off from the limestone hills to the Kuskokwim flats suggests that a fault of considerable magnitude may occur here. Whether or not this is the correct explanation of the structure, the fact remains that the country north of the limestones is so deeply covered with recent deposits that no valuable structural observations have been made within a distance of about 50 miles northwest of the limestones. North of this point as far as Iditarod the rocks are in rather open folds, whose axes trend about northeast. Beyond Iditarod Paleozoic rocks are again exposed, as if on the southern flank of another structural system possibly similar to that near the Paleozoic limestones already described.

To the deformation by which the Pacific mountain system was produced, the structural features of the Lake Clark-Iditarod region seem to be mainly due. This deformation was apparently greatest in the Alaska range, the Chigmit Mountains, and the Aleutian range. In places remote from this main axis the amount of deformation is less, so that the major structure appears to become more regular toward the west and northwest. In no place in this region, however, is the structure of the pre-Tertiary rocks simple, and as a rule the dips are more than 30°.

GENERAL ECONOMIC CONDITIONS.

WAGES AND SUPPLIES.

Few mines and prospects are being developed in the Lake Clark-Iditarod region except in the immediate neighborhood of Iditarod, and information about many of the factors that determine the success or failure of mining ventures is rather meager. It has seemed desirable, however, to discuss the prevailing general conditions, for, although these would undoubtedly change if mining should increase, they afford the only sure basis from which deductions as to the future economic conditions may safely be made.

Wages during the summer for miners at the small mines near Iditarod are $5 a day and board, but at some of the larger mines they are $4 a day and board. In the more remote districts the usual wages are $7.50 and board, the board being assumed by the operators to cost about $2.50. Practically no natives are employed in the producing mines, and probably they are too few ever to have a marked effect on the cost of labor. Along Kuskokwim River, however, the usual wages paid to a native are $2 a day and board. This is also about the price demanded for native labor on Iliamna and Clark lakes. Nearer to the settlements of whites, in the interior, the natives usually receive somewhat more. Owing, however, to the fact that most of the natives' wages are paid in trade, the actual cost is considerably less than if they were paid in cash.

During the winter, when shallow placer mining is prevented by snow and ice, fewer men are employed and consequently the oversupply of labor tends to lower the wages paid. If more employment were obtainable during the winter, owing to an increase in deep placer mining or through the development of lode mines, this difference between winter and summer wages would probably decrease, but the summer wage would probably go down rather than the winter wage go up. This conclusion seems warranted by the fact that many more persons would find permanent employment during the seven or eight winter months that the shallow placer mines are now closed and would not be compelled to support themselves for an entire year on the proceeds of their labors during the four or five months of the open season. It is therefore believed that the general tendency of wages in the future will be to decrease.

In an area so remote as much of the Lake Clark-Iditarod region supplies of all kinds are expensive. This is inevitable because of the long transportation all goods must undergo, the dangers of loss or damage to which they are subjected in transit, the short time available for bringing them in, the need of an exceptionally large reserve supply, the financial uncertainty as to the stability of the boom towns and the merchants who flock to newly organized camps, the high cost of wages and the attendant high overhead and construction charges, the various social and educational disadvantages inherent on life in a remote region, which justify a larger income from investments, and the many other real though less tangible hardships to which all frontier life is subjected. With the natural changes that follow the permanent settlement and development of the region many of the drawbacks become less or disappear, so that the general tendency will be for the cost of supplies to decrease. Already the cost of supplies has been lowered several hundred per cent in less than four years. As an instance, in 1910 oats and hay sold in Iditarod for over 20 cents a pound, but in 1914 they sold for 6 cents a pound. Even at present, however, in remote parts of the district high prices prevail, and 25 cents is the smallest unit used.

Although prices are high when judged by the standards of the eastern United States, the supplies carried are usually of good quality and of great variety. The stores seem to carry a much better assortment of supplies than stores serving a settlement of similar size in the States. This is due in large measure to the exceptionally generous scale on which most Alaskans live. In the matter of food, for instance, even the poorest prospectors usually have canned milk, butter, and other things that elsewhere may be regarded as luxuries. Possibly this demand for a liberal ration is caused by the severe cold and the long-continued darkness to which the Alaskan people are subjected in the winter.

TRANSPORTATION.

One of the important items entering into all mining calculations is that of transportation. Not only does it materially affect the cost of supplies, but it may even determine the feasibility of an enterprise. To appreciate the importance of transportation it should be realized that practically the only ice-free winter route from the States to this part of Alaska leads to one of the small bays on the west side of Cook Inlet. From that place the route to the interior lies across the general trend of the country, so that several ranges must be traversed. A route of this sort presents many difficulties which add to the cost and time of transportation.

The more natural highways by way of Kuskokwim and Yukon rivers are blocked by ice from October to June. Furthermore, both of these streams lie north of the winter limit of sea ice, so that they can not be reached by boats from the States for seven months of the year. Therefore, although the rivers offer a water grade for hauling supplies and are much used for this purpose, they are of much less value than they would be if at least parts of them could be reached during the whole year by boats from the outside world.

During the winter, transportation is effected mainly by dog teams or, on well-beaten trails, by horse-drawn sleds. Road houses are maintained at intervals along the main lines of travel and afford food and shelter for both persons and animals. The main winter trail from Iditarod to the sea used for the transportation of mail runs in general eastward to Takotna, thence to McGrath, thence up the Kuskokwim across the divide at Rainy Pass, thence southeastward in the basins of Skwentna and Yentna rivers to the crossing of the Susitna at Susitna, and thence to Knik, a distance of about 500 miles. From Knik the usual trail is followed to Seward, where all the year around connection by steamboat with the States is maintained. Other much-traveled trails lead from Iditarod to the Yukon and the Tanana. Many of these trails are staked and flagged by the Alaska Road Commission, so that they are recognizable even in severe storms, which are by no means infrequent.

In summer the main lines of transportation to the region from the States are by a sea trip to St. Michael and thence up Yukon River, or by the so-called "inside passage" to Skagway, thence by rail to Whitehorse, and thence down the Yukon. The coastwise steamships that call at the ports on the southern coast of Alaska afford a third means of approaching the area. However, this route presents the difficulty, already pointed out, that from the western shores of Cook Inlet no easy route of transportation into the interior has been developed. Small ocean-going vessels can ascend the Kuskokwim in summer as far as Bethel, but no regular trips are made by this route.

The two main summer lines of transportation within the region are by Yukon and Kuskokwim rivers. A fleet of shallow-draft river steamers, operated by the White Pass & Yukon Route, follows a more or less definite schedule on Yukon River. Smaller boats belonging to the same company run up Innoko and Iditarod rivers to Dikeman. Above that point still smaller boats, operated by other companies or individuals, complete the water trip to Iditarod. Several individuals and independent companies also run river boats on irregular schedules to the Yukon and Innoko river ports.

On the Kuskokwim shallow-draft river steamers or launches run up the river from Bethel as far as Takotna. These boats seldom make more than three or four round trips a season, and the amount of freight they carry is small.

The recent decision of the Government to build a railroad to develop parts of Alaska called attention to the possible routes from the southern coast into the interior. Among others the route from Iliamna Bay to Iditarod and Yukon River was considered by the Alaska Railroad Commission,[1] but while its value for local uses was recognized it was dismissed by the commission, as it "is too far to the southwest to permit its use as a trunk line into the interior." This route had been privately surveyed in part and the papers on it had been filed in Washington in the General Land Office. The route presents no very difficult engineering problems and would afford easy grades into the interior, but much of it would lie in a country holding, so far as known, little promise of much economic value in the near future.

During the summer transportation within the region is carried on mainly by boats on the rivers and by horses or back-packing on cross-country trips. A few wagon roads have been built, but most of them are so wet and muddy that only very light loads can be drawn on them. In striking contrast to the other roads is the one from Flat City up Flat Creek. This compares favorably with many roads in the States, and although it was expensive to build it shows that good roads can be made even under the adverse conditions which are met in this part of Alaska.

A tram road for horse-drawn cars running on wooden rails connects Iditarod and Flat. This tram road is in operation only during the summer and carries freight the 8 miles between the two towns for 2 to 3 cents a pound. It undoubtedly could be kept open in winter, but at that time of year transportation across country is much less difficult than in summer and the people are not otherwise engaged, so that they can profitably do their own freighting.

[1] Railway routes in Alaska: 62d Cong., 3d sess., H. Doc. 1346, p. 8, 1913.

POWER.

At present the only place where power is in much demand is in the vicinity of Iditarod. At that place power for various uses is produced mainly by the use of wood or mineral oils as fuel. Timber was at one time fairly abundant in that region, but with continued cutting the supply is becoming less easily available. At one of the larger mines about 5,000 cords of wood is used each year for producing motive power and for thawing the frozen ground containing the placer gold. The manager estimates that the wood delivered at the boilers costs from $15 to $18 a cord. The supply of wood in the vicinity of this power plant has become so small that a new location nearer the river has been selected, and the wood will be used to generate electric power, which can be cheaply and effectively transmitted to the places where it is to be used for mining. The wood for this plant is cut in the more remote valleys and floated downstream to the site of the power plant, where it is cut into cordwood lengths. At the new plant the wood should not cost much more than $6 to $8 a cord.

Not only is wood used at the larger mines, but it is also the main source of the power used on the larger boats. The wood for the steamers does not cost so much as that used at the mines, for it does not have to be transported so far. Consequently most of the wood for the boats is sold at about $6 to $7 a cord. Most of the small boats and launches use gasoline or distillate for fuel. This fuel is also used on one of the dredges and at some of the smaller mining properties. The cost of distillate in small lots at Iditarod in 1914 was $5 a case of 10 gallons.

No water powers with volume larger than a few sluice heads have been developed in the region. Almost no coal is used.

The few facts regarding power given above have been taken entirely from data obtained in the immediate vicinity of Iditarod. In order to use this information for other parts of the region the facts require modification to fit the local conditions of the area to which they are to be applied. As a rule the determination of the amount of modification required will depend in large measure on personal judgment, but help in reaching a decision may be afforded by consulting the map (Pl. X) showing the distance and the available routes to the project under consideration. Increased transportation facilities may be expected to decrease the cost of oil fuels that are shipped in from a distance, but probably they will only slightly affect the cost of wood for fuel, because the depletion of the supply will more than counteract the improvement in the means of transportation.

MINERAL RESOURCES.

KINDS AND DISTRIBUTION.

The mineral resources of the Lake Clark-Iditarod region outside of the immediate vicinity of Iditarod have been so slightly explored that those at present known probably are only a part of the resources that full examination of the area would disclose. In the following pages a description of the developed deposits will be given, and attention will be drawn to those places in the undeveloped areas where geologic conditions indicate that similar deposits may be sought with some assurance of success.

The principal developed metalliferous deposits of the region are those in which gold is the mineral of value. This is due not only to the widespread distribution of gold, but also in large measure to the ease with which it is obtained in a nearly pure state and the consequently small charges for elaborate machinery, refining, or transportation of nonmetallic material. The gold deposits that have been most extensively developed are the placers, none of the gold lodes having yet reached more than the prospect stage. This is probably due to the ease of recovering the gold from placers, rather than to the absence of lodes. Gold placers have been mined in the vicinity of Iditarod, on Otter Flat, Chicken, and Happy creeks, and other tributaries of Iditarod River; on the Takotna and some of its side streams which are in the Kuskokwim basin; in the valley of Crooked Creek, a tributary of the Kuskokwim just west of the area described in this report; on the Holitna; on Bonanza Creek and the bars in the Mulchatna basin; and on Caribou Creek and Keejik River, in the Lake Clark drainage basin.

The only gold lodes that are being prospected are northwest of Lake Clark and at Candle Creek, on the Takotna. Neither of these was visited by the Survey expedition of 1914, and the only information regarding them was gained from prospectors and from the local papers. Some gold is associated with the base metals in the other lodes of the region.

Quicksilver has been reported at several places in the basin of the Kuskokwim. It occurs both in lodes in the form of cinnabar, the sulphide of mercury, and in gravel deposits in the form both of cinnabar and of native mercury. The occurrence in the gravels does not appear to be of much importance commercially. A description of the quicksilver deposits is given in a separate article by the writer and A. G. Maddren in another part of this volume (pp. 272–291).

Other metals, such as copper, antimony, silver, lead, molybdenum, and manganese, have been found in or near the region, and some of the deposits have been more or less developed. Copper has been

reported at several places, and deposits have been prospected near Iliamna Lake and in the vicinity of Lake Clark. It occurs combined with sulphur in the form of the mineral chalcopyrite.

Antimony occurs most commonly as the sulphide, stibnite. It has been found associated with the mercury ores on the Kuskokwim and in the Iditarod basin in the vicinity of the igneous contacts. None of the stibnite deposits have been developed.

Silver-bearing lead ore, or argentiferous galena, has been found and opened to some extent in the hills south of Iliamna Lake. This place lies outside of the area described in this report, but is so close to it that similar deposits may be found within the area.

Molybdenite, the sulphide of molybdenum, has been found in small quantities in deposits west of the north end of Lake Clark. This ore carries some gold, and it is mainly on account of that metal that the deposit is being prospected.

Deposits containing manganese have been found in the same region as the silver-bearing galena. The mineral is the black manganese oxide. The same mineral has been reported also in the basin of the Kuskokwim.

Coal has been found at a few places adjacent to the town of Iditarod, in the central part of the Holitna basin, and in the Kuskokwim Valley south of Bethel, outside of the region here described. Rocks which elsewhere in Alaska are coal bearing have a rather wide distribution in the Lake Clark-Iditarod region, so that investigation of unexplored parts may considerably increase the number of known coal exposures. No deposits of oil nor of gas have been reported in this region, though they occur on the west coast of Cook Inlet, north of Iliamna Bay.[1]

The water resources of the area have been developed only on a small scale locally to meet domestic and mining needs. Fuller settlement and development of the region will undoubtedly necessitate examination of the now undeveloped water resources.

Each of the mineral resources above mentioned will be described in some detail in the following pages, and the known facts of geologic significance about each will be given. The information is far from complete, but may be of service to prospectors, investors, and others contemplating mining work in the region.

GOLD DEPOSITS.

IDITAROD REGION.

The gold deposits of the Iditarod region have been studied in some detail by Maddren and Eakin, and although some of the more accessible deposits were seen by the writer, the observations of the other

[1] Martin, G. C., and Katz, F. J., op. cit., pp. 126–128.

geologists have been so recently published that restatement of the details here seems inadvisable. Inasmuch, however, as the only active mines are situated in the vicinity of Iditarod, a summary of the general features may be of service in indicating the conditions under which the gold occurs and so furnish clues as to conditions under which it is likely to be found in the unprospected parts of the region.

According to Eakin:[1]

Twenty-nine claims, located on eight different creeks, were worked in the Iditarod district in 1912. Thirty-six plants were engaged in the work. Of these 1 was a dredge, 22 were equipped with steam machinery, and 13 used manual methods. A total of about 975 men were employed. The value of the total gold production of the district, including Moore Creek (a tributary of the Takotna), for the year 1912 was probably a little in excess of $3,500,000.

In 1914 an additional dredge was running part of the season, about 15 plants, employing 500 men, were in operation, and the gold production reached about $2,060,000; otherwise the conditions were similar to those prevailing in 1912.

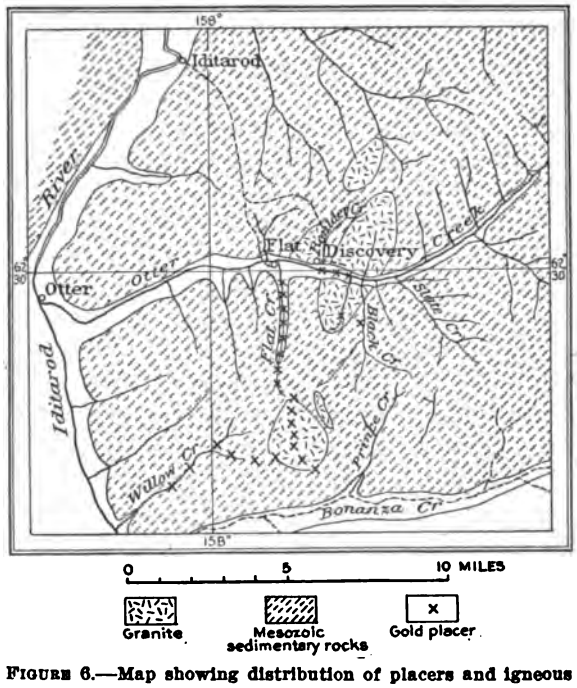


FIGURE 6.—Map showing distribution of placers and igneous rocks in the vicinity of Iditarod.

The gold comes entirely from placers, of which two distinct types are recognizable. In one the gold occurs in the stream gravels, forming typical creek placers; in the other it occurs associated with disintegrated but non water-sorted material, forming residual placers. Both types are areally associated closely with plutonic igneous rocks of granitic character. Figure 6, a copy of part of the geologic and economic map accompanying the report by Eakin,[2] shows the close relation between the distribution of the placers and that of the igneous rocks in the vicinity of Iditarod. No placers other than those shown on the figure are mapped by

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, pp. 35, 1914.

[2] Idem, pl. 3.

Eakin within 30 miles of Iditarod. This close relation is of the greatest importance in furnishing a clue to the places in near-by undeveloped areas where prospecting is justifiable.

Mining in the vicinity of Iditarod is carried on mainly by small plants. The general conditions do not differ materially from those encountered in placer mining in other parts of Alaska. Two dredges have been installed—one on Flat Creek and the other near Discovery claim, on Otter Creek—and are in successful operation. One of these is equipped with buckets having a capacity of 7 cubic feet. It is capable of handling over 4,000 cubic yards of gravel a day and has a working season of about 175 days. This dredge is operated by electricity, which is produced at a plant located near the mine. The ground mined is in general permanently frozen, so that it is artificially thawed before being dredged. Thawing is done by steam generated by the use of wood as fuel. The steam points are usually set only 8 feet apart, and more than 25 men are required for the thawing operations, which are therefore expensive. The depth that is dredged is seldom over 25 feet and the average is between 10 and 15 feet.

The success of this enterprise seems to be due to the high tenor of the gravel, owing to its derivation in large part from the near-by contact area, to adequate financial backing, and to efficient management. The efficiency of the management is shown not only in the actual handling of the dredging operations, but also in the thorough preliminary sampling of the ground, in the careful investigation of the incidental problems, such as the effectiveness and cost of thawing and in the close scrutiny of costs, so that wasteful or expensive practices are discovered and remedied.

The smaller plants, employing mainly hand labor, are confronted with many of the problems already noted. However, because the area of placer ground mined by them is less and the cost per unit is greater, the richer placers only are sought. The material usually mined, except in the residual placers, is permanently frozen, so that the expense of thawing must be provided for. Most of the small mines have worked the shallower placers, and consequently are situated near the heads or on the slopes of the valleys. Under these conditions a considerable volume of water for sluicing or for mechanical purposes is obtainable only at high cost. The larger plants, employing powerful machinery, are able to work deeper placers and consequently are usually located in the valley bottoms, where the alluvium is deeper and the volume of the streams greater. However, the gradients of the valley floors are so low that a large supply of water at a considerable head is not obtainable except by ditches tapping the supply a long distance upstream from the mine. Some of the operators have tried to overcome this difficulty by pumping water from the

larger tributary streams with gasoline engines, but this practice has usually been so costly that it has been abandoned.

KUSKOKWIM BASIN.

In the part of the Kuskokwim basin included within the Lake Clark-Iditarod region gold has been reported in the Takotna, George, Crooked, and Holitna basins, as well as at places on the main stream. In the Takotna basin the two places where gold has been found in commercial quantities are on Moore Creek, near the head of the main Takotna, and on Candle Creek, a small tributary of Tatalina River, which is the large southern affluent of Takotna River. The placers of Moore Creek have been mined for several years on a small scale. A stampede to this creek took place in 1910, but in 1912, according to Eakin,[1] only one claim was in operation. In 1914, so far as could be be learned, three mines were operated, employing about 13 men. Only pick-and-shovel methods were used in mining the shallow placers on this creek. A project was under way to bring in a gasoline-driven drill to test the deeper and more extensive deposits of Moore Creek, but no report has been obtained as to the success of the enterprise.

On Candle Creek auriferous placer ground was prospected during the winter of 1913–14 by means of a Keystone drill and by shafts, and good returns were reported. A mine equipped with steam bucket hoist was operating on this property in the summer of 1914. The depth of the deposit carrying the gold ranged from 10 feet near the head of the valley to 56 feet in the lower part. The gold near the head of the creek is reported by Maddren[2] to occur in residual granitic sands. The occurrence seems essentially identical with that of the residual deposits at the head of Flat Creek, in the Iditarod district, with stream placers extending downstream similar to those that occur on Flat Creek.

No mining has been in progress recently in the George River basin, but a rush of gold seekers invaded the headward part of this valley in 1910 and staked claims over much of the region. At that time Julian Creek was said to afford the best showing for placers, but in 1914 no one was permanently settled on the creek. This stream has not been visited by the Survey parties, but its geology is said to be similar to that of the placer areas already noted, in that the sedimentary rocks are cut by granitic intrusives.

An account of the placers on Crooked Creek is given elsewhere in this volume (pp. 351–353).

Gold has been found at a number of places on the Holitna, but the only definite report concerning that region has been given to the Survey by Mr. W. R. Buckman, a prospector who spent the winter of

[1] Eakin, H. M., op. cit., p. 35. [2] Maddren, A. G., oral communication.

1902–3 in the basin of that stream. He states that small amounts of gold were found in many parts of the basin. On bars in the lower part of this stream accumulations of black sand with minute particles of gold were found, especially a short distance above the place where the Holitna is joined by the Hoholitna. On the headwater branches colors of gold were found in the lower parts of all the streams, but nearer the mountains the number of colors decreased and the indications of placers were less promising. The lower parts of these streams were difficult to prospect, as the gravel was unfrozen and consequently the ground was very wet. The gravels are composed of a variety of different rocks, including granite, sandstone, greenstone, quartz, conglomerate, and a little limestone. No placers that could be profitably mined were found. Considering the immense size of the area to be investigated and the difficulties of prospecting, the negative results obtained by this prospector in the short time spent on the search do not prove that further investigations of the region will not disclose workable deposits.

Two different outfits of two men each started up the Holitna late in August, 1914, intending to spend the winter prospecting in the upper part of the basin.

The occurrence of gold on the main Kuskokwim was noted by Spurr[1] in 1898, and he seems to have recognized its mode of occurrence so accurately that his description, which follows, is entirely adequate to-day:

> As soon as the Kuskokwim leaves the vicinity of the Tordrillo Mountains, however, and flows through the Tachatna series and the succeeding Cretaceous rocks it seems to be entirely without any gold in its gravels. An exception to this was at the mouth of the Chagavenapuk, where the gravels contain many colors of fine gold, but these gravels consisted of the characteristic dike rocks of the Terra Cotta Mountains, where the stream heads, and undoubtedly the gold together with the gravels had been brought from this source. In the region below Kolmakof, where siliceous dike rocks again cut through the mountains, it is reported by traders that gold occurs in small quantities.
>
> The gold on the Kuskokwim, therefore, is * * * derived from the mineralized rock and the quartz veins which result from the action of ore-bearing solutions accompanying or following the intrusion of Eocene dikes.

MULCHATNA BASIN.

Gold has been reported from several parts of the Mulchatna basin. Spurr[2] states:

> As early as 1890 three prospectors, Harry Mellish, Percy Walker, and Al. King, are said to have ascended the Mulchatna 200 miles, and there to have found gold, which, however, was too fine and flaky to save. A few prospectors have been wintering on the Mulchatna the past season (1898), but the result of their explorations is not yet known. From one of them, Mr. Murkle, who came back after a month or two, the writer learned that fine colors had been found on the Mulchatna, but none on the Swan.

[1] Spurr, J. E., op. cit., p. 250. [2] Idem, p. 261.

In 1909 Katz[1] visited the Iliamna region and obtained the following notes on the gold deposits in the Mulchatna basin:

On the Mulchatna, from the Koktalee up, and on the Koktalee also fine flour gold is found on all the river bars. Bedrock has not yet been prospected along these larger streams on account of ground water. Only summer work has been attempted so far, and as yet no permanent ground frost has been encountered. It is claimed that after May 15 no thawing is required. Above the forks of the Mulchatna, particularly on the middle fork, the gold so far found is coarser, and there is said to be pay. Some of the smaller tributaries carry coarse gold. On one of them two men opened a hole in 1909 and took out about $8 worth of coarse gold.

The prospecting so far has been confined to the present stream beds. The pay is said to be practically all on bedrock, which is reported by the prospectors to be chiefly slate. Limestone and "porphyry" bedrock also are reported. The gravels prospected are generally from 4 to 12 feet deep; one hole is 16 feet deep.

In 1914 the only prospecting for gold in the Mulchatna basin is reported to have been on Bonanza Creek. This is apparently a small stream, heading in an isolated group of hills, flowing in its middle course in a steeply incised gorge and in its lower part in a rather wide gravel-floored lowland of the middle and northern forks of the Mulchatna. A small camp, consisting of about six persons, has been established. This place was not visited, but from what are believed to be reliable reports it was learned that a hole 65 feet deep had been recently sunk to bedrock and gold discovered. Granitic intrusive rocks, cutting the sandstone and shale country rock, were found in the hills south of this creek, and probably their contacts were the source from which the mineralization was derived. No information as to the value of the placers found has been received, and the lack of actual investigation of the region makes conjectures as to the probable value almost worthless. Nevertheless, the impression gained from the study of adjacent regions was that while workable placers may occur their distribution must be irregular, or, as the miners say, "spotted," and they must be rather closely limited to those areas which derive placer material mainly from the contact zones that surround the igneous intrusives.

LAKE CLARK-ILIAMNA LAKE BASIN.

According to Katz:[2]

The effort to discover placers on the drainage tributary to Lake Clark from the north has not met with encouraging results. Prospects have been found on Caribou Creek, a northeasterly tributary to Chulitna River; on Kellet Creek and Ingersol, Lincoln, and Franklin gulches, which are headwaters of

[1] Katz, F. J., Notes on the Mulchatna region: U. S. Geol. Survey Bull. 485, pp. 131–133, 1912.

[2] Martin, G. C., and Katz, F. J., op. cit., p. 126.

Kijik River; and on Portage Creek, which enters Lake Clark about 85 miles above the outlet of the lake and which heads against the last-mentioned streams. These streams were not visited by the Survey party, and little information about them was obtained. Two men are reported to have done considerable work on Portage Creek, which netted a few hundred dollars' worth of coarse gold. It was further reported that they found the alluvium to be about 12 feet deep and composed chiefly of large glacial bowlders.

When the region was visited in 1914 no claims other than those at the head of Lake Clark were being prospected, and operations on these consisted of little more than the annual work required by law. A quartz vein had rather recently been discovered on the upper part of Kijik River, about 10 miles northwest of the extreme head of Lake Clark. The lead is reported to cut granitic rocks and is probably a pegmatite vein. The gold content is reported to be sufficiently high to make mining profitable, but the great expense necessary for the opening of a property at this place will probably preclude active development in the near future. Associated with the quartz and gold in this vein are small, irregularly distributed crystals of molybdenite, the sulphide of molybdenum. This mineral is in platy bluish silvery flakes, the largest aggregates of which are about half an inch in diameter. The occurrence of the molybdenite and the presumable pegmatitic character of this gold-bearing vein point to the conclusion that the vein was formed at moderate to high temperatures.

POSSIBLE FUTURE AREAS.

From the foregoing account of the places where gold-bearing deposits have been reported certain general conclusions may be drawn. The most important of these is that auriferous mineralization is closely associated with the intrusion of granitic igneous rock. This conclusion does not mean that gold deposits will be found wherever these igneous rocks occur, for many other factors determine the places where ore bodies are formed. It does mean, however, that the contact areas near the igneous intrusives are the most promising areas in which to prospect for mineralization and possible ore bodies. The positions of all known areas of igneous rocks of this sort have been indicated on the map accompanying this report (Pl. X). Much of the area, however, is still unsurveyed, and probably these rocks occur at other places. From the mode of occurrence at the known localities the occurrence of the igneous rocks that may be found in the unsurveyed areas is probably essentially similar—that is, these rocks have an irregular distribution and a rather small areal extent.

Judged from the facts now known, a great part of the mineralization is disseminated throughout the country rock near the contacts with the igneous rocks. Although in a region of disseminated min-

eralization the search for lodes may not be successful, the search for placers may be rewarded. The same general laws apply to prospecting for placers, however, as to the search for lodes, but certain other features must also be considered. The drainage must be so arranged that a considerable amount of the mineralized contact zone is traversed by the stream on which placer ground is sought, the concentration must have been effective, and the placer accumulation once formed must not have been subjected to any destructive erosional activity, such as glaciation, which has removed it.

In some parts of the region, notably in the basins of Kuskokwim and Mulchatna rivers and in the area draining into Lake Clark, the heavy outwash deposits from the former glaciers have mantled over the low parts of the region so deeply that whatever placer accumulations may have been formed before the glaciation are now in large measure concealed. Under these conditions prospecting is difficult, for it requires an understanding of the general geologic and physiographic history of the region in order to select the best places to examine in detail, and in addition requires an outfit suitable for prospecting the buried deposits. Upstream from the outwash deposits the streams are usually eroding bedrock or earlier stream deposits, and small placers are likely to be found. In many of these places, however, the streams are cutting down their courses and eroding the hard rock. This work has been in progress for so relatively short a time and the rocks attacked have weathered so slightly that the concentration of the valuable heavy mineral usually has not resulted in rich accumulations. Where the streams are cutting down in former stream deposits containing possible gold accumulations the renewed erosion may possibly effect additional concentration into very rich placers. In most places of this sort, however, the courses of the earlier and the present stream would not coincide in all parts and as the rich concentrations would be more or less limited to the places where they did coincide the distribution would be decidedly irregular. The prospector might, therefore, find rich spots here and there along the stream, whereas the surrounding area would not be rich enough to warrant mining.

Furthermore, the probable irregular distribution and rather small extent of the mineralized areas would not lead one to expect, from present indications, a widespread distribution of placers such as is common in areas like Seward Peninsula and the Fairbanks district, where colors of gold may be found on almost every stream or in every deposit of the unconsolidated rocks.

To summarize, the present conditions indicate that placers may occur in parts of the region traversed by the Survey party of 1914, but probably they are not widespread or regular in their distribution.

They may hold out promise of adequate returns to the observant and skilled prospector, but for others they will be difficult to find and costly to operate. So far as has been seen the chance of finding gold lodes that can be worked at a profit in the near future does not seem encouraging.

COPPER DEPOSITS.

Copper-bearing deposits have been developed only in the adjacent Iliamna-Lake Clark region. These have been described by Katz[1] as follows:

> The copper deposits of this region may be referred to two classes: (1) Chalcopyrite deposits in limestone—(*a*) associated with minerals of contact-metamorphic origin and (*b*) without evidence of contact-metamorphic origin; (2) chalcopyrite in quartz veins in greenstone and in granite.
>
> Only the deposits in the limestone have as yet developed any prospective value. These are known at four localities—2 miles west of the head of Iliamna Bay; 9½ miles west-northwest of the head of Cottonwood Bay; on Kasna Creek near Kontrashibuna Lake; and at Millet's, on Iliamna Lake 22 miles west of Iliamna village. At each of these localities the mineralization is in limestone near its contact with an igneous formation. At the last-mentioned place the contact is not exposed and there is no evidence as to its nature. At the other localities there are diorites or diabases intrusive into the limestone. The limestones are metamorphosed by coarse recrystallization of the calcite and the development of garnet, epidote, magnetite, hematite, and quartz, besides the sulphides pyrite and chalcopyrite. These developments in general are close to and parallel with the igneous contacts, but from place to place along these contacts they vary considerably in mineral association, in shape, and in size. They are irregular and nonpersistent. In all their features—their geologic position, mineralogy, and outline—they have the characteristics of contact-metamorphic deposits.

From what is now known of the general geology of the Lake Clark-Iditarod region few places seem to hold promise of containing deposits of copper-bearing minerals similar to those of the area just described. The general statements that have already been made concerning the probability of finding gold lodes apply also to the copper lodes. In addition, however, the lower value of copper and the greater cost of producing it in a refined state make a copper property probably much more expensive to develop than a deposit of free gold.

ANTIMONY DEPOSITS.

Stibnite, the sulphide of antimony, has been found at several places in the Lake Clark-Iditarod region, notably at Parks mercury prospect and in the divide near the head of Glen Gulch. The occurrence of the antimony ore at the mercury prospect is described somewhat fully elsewhere (pp. 278–280), so that further description here is unnecessary.

[1] Martin, G. C., and Katz, F. J., op. cit., pp. 116–117.

The occurrence of stibnite near the head of Glen Gulch has been examined by Maddren,[1] from whom the following facts were obtained. Stibnite occurs mainly in the larger quartz veins and near the contact of the granites and the sandstone and shale succession of rocks. One of these shattered contact zones at the head of Glen Gulch was prospected by means of open cuts, but the stibnite was found to be so irregularly distributed that the deposit could not be profitably worked under the existing conditions. This prospecting was not intended primarily to develop a lode valuable for its content of antimony, but rather one valuable for its content of gold.

Particles of stibnite are found in the concentrates from many of the placer claims and have doubtless been derived from the same source as the gold. The placers at the head of Flat Creek afford perhaps the best illustration of this condition.

The conclusion that the stibnite mineralization is closely associated with the intrusion of deep-seated igneous rocks of the granite family is indicated by the foregoing facts. The low price of antimony and the high cost of production make the probable commercial development of deposits of this metal in the near future in this region extremely doubtful. Inasmuch, however, as the antimony ore also carries some gold, possibly in some places the gold tenor may be great enough to warrant exploitation of the auriferous stibnite lodes.

SILVER-LEAD DEPOSITS.

No silver-lead deposits have been found in the Lake-Clark-Iditarod region, but in the Iliamna region, to the south, one deposit has been reported. This deposit was described by Katz and the following notes[2] are abstracted from his published report:

Silver prospects have been found in the limestone belt which extends southwestward from Iliamna village. The silver claims aggregate about 2 miles in length. However, but one group of eight claims has been developed sufficiently to make investigation possible. The only silver minerals disclosed are argentiferous galena (the sulphide of lead) and argentiferous sphalerite (the sulphide of zinc), which are also manganiferous and which occur in veins. In addition to these minerals manganiferous limonite and lead-bearing ocher, small amounts of smithsonite (zinc carbonate), and selenite (lime sulphate) are present in weathered parts of the veins. Pyrite is only locally and sparingly developed. Calcite and quartz, in veins that have been crushed, are found near the metalliferous veins but do not occur as gangue minerals in them. The limestone has been cut nearly at right angles to its strike by many small vertical dikes. Several larger dikes

[1] Maddren, A. G., oral communication.

[2] Martin, G. C., and Katz, F. J., op. cit., pp. 124–125.

and irregular masses were also observed, most of which are parallel to the strike of the limestone. The ore bodies appear to have been formed along fissures in the limestones. The fracture zones seem to be vertical. Along these the limestone is brecciated, and some pieces are slickensided. To judge from the material collected, the galena, sphalerite, and small amounts of pyrite filled the fractures. To some extent also the limestone is impregnated with these sulphides.

No production has been made from this property, but the owners report that samples have yielded from 80 to 196 ounces of silver and as much as $20 in gold to the ton, 35 to 50 per cent of lead, and 15 to 20 per cent of zinc. The black manganiferous gossan, they report, carries 2 to 6 ounces of silver to the ton.

MOLYBDENUM.

The only known occurrence of mineral containing molybdenum in the region is on Kijik River about 10 miles northwest of the extreme north end of Lake Clark. Little is known about the geologic conditions at this place. Apparently the molybdenum occurs as molybdenite in scattered flakes, in what is presumably a pegmatite vein closely associated with granitic intrusive rocks. So far as learned the molybdenite is not sufficient in amount to have commercial value on its own account, but the fact that the vein is said to carry some gold may make development of the property possible.

MANGANESE.

Manganese, as has already been noted (p. 267), occurs in the silver-bearing lead deposits south of Iliamna village. At that place it has not been utilized and apparently has no commercial value.

Dall[1] states that "black oxide of manganese has been received from the Kuskokwim." He gives no further notes concerning the locality from which the specimen was obtained nor concerning the mode of occurrence.

COAL RESOURCES.

In many parts of Alaska the Cretaceous rocks, which in general are similar to the bedrock of a large part of the country north of Kuskokwim River, are coal bearing. So far, however, no workable coal deposits have been found in the basin of the Kuskokwim within the area here called the Lake Clark-Iditarod region. At a few places on the hills east of Iditarod, however, coal crops out, and attempts to mine it have been made. Coal has also been reported on Big River and on the Holitna. Probably by more extensive exploitation other coal deposits will be found, but from what is now known of the coals

[1] Dall, W. H., Alaska and its resources, p. 478, 1870.

of this geologic horizon, although they may be of economic value in a region of scanty fuel, they are not as a rule of sufficient value to allow their being transported far, and they can not be cheaply mined.

The coal deposit on which most development work has been done is situated on the tram road from Iditarod to Flat, about a quarter of a mile south of the crest of the divide between Otter Creek and Iditarod River. At the time of the writer's visit the property was lying idle and the excavations had filled with water. The following notes were obtained from Mr. W. W. Acheson, of Iditarod, who was familiar with the mine when it was in operation. The bed of coal which was exposed at the surface dips about 45° southwest. It is about 40 inches thick, and its walls are very smooth and in places slickensided. Near the surface considerable slate was mixed with the coal, but lower down the slate decreased in amount, so that at a depth of 50 feet it was almost entirely absent. This prospect had been developed by a 40-foot vertical shaft, from the bottom of which a 20-foot incline on the coal bed had been driven.

The coal on the dump appears to slack badly and when mined is intersected by numerous veins of ice. Many of the small pieces of coal on the dump have polished and slickensided surfaces. It has been used locally as fuel in the road house near by and also in a blacksmith's forge, but was not very satisfactory for the latter use.

The character and fuel value of the coal are not definitely known, for the information from the different sources was not in accord. A sample said to have been taken from this property, received from Charles Estmere, of Iditarod, according to Brooks[1] was analyzed by A. C. Fieldner, chemist of the Bureau of Mines, with the following results:

Analysis of coal from locality near Iditarod.

[Air-drying loss, 0.0]

	Air-dried.	As received.	Moisture free.	Moisture and ash free.
Moisture	1.40	1.42	.....	.....
Volatile matter	6.60	6.60	6.70	7.23
Fixed carbon	84.75	84.73	85.95	92.77
Ash	7.25	7.25	7.35	.....
	100.00	100.00	100.00	100.00
Sulphur	1.10	1.10	1.12	1.21

Mr. Fieldner adds the following statement: "This analysis indicates that the coal is anthracite. The sample received was chiefly

[1] Brooks, A. H., The Alaskan mining industry in 1913: U. S. Geol. Survey Bull. 592, pp. 72–78, 1914.

slack, and the data at hand indicate that the coal bed is crushed. It is doubtful whether this coal could be utilized without briquetting."

A somewhat different statement as to the character of the coal was given by Mr. Acheson, who says that the material ignites rather easily and has the physical features of lignite. Perhaps these two discordant views can be reconciled by assuming the coal to be normally a lignite or subbituminous coal, similar to the other known Cretaceous coals, and that it has been metamorphosed locally into an anthracite through the deformation and shearing to which it has been subjected.

Coal has also been reported from several other places in this same neighborhood. An exposure of coal is said to have been found on the Iditarod side of the Iditarod-Flat divide, at a point about a mile northwest of the locality previously noted. No mining has been done at this place, and the character and extent of the coal have not been determined.

Northeast of the locality last mentioned are other coal croppings that have been slightly exploited. No work was in progress at that place, and the old pits were not visited. Some coal has been taken out, however, and it is said to have been used in Iditarod with satisfactory results, though probably at most not more than a few hundred pounds has been so used.

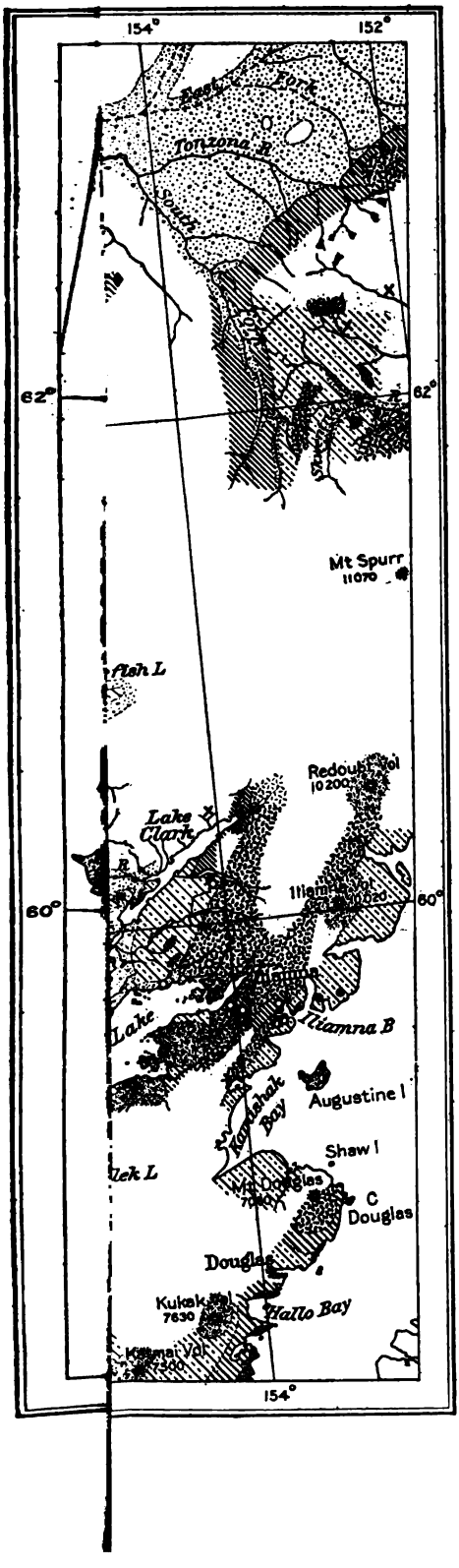
Coal-bearing rocks have been reported to crop out on the Holitna at two places. One of these is about midway between the mouth and the head of that river, and the other is some distance farther upstream. The deposits have not been carefully investigated, but the discoverer of them says:[1] "The coal indications on the Holiknuk [Holitna] are not extensive enough to permit the assertion that they will in time be of commercial importance."

Coal deposits have also been reported to occur on the western flanks of the Teocalli Mountains, on the eastern slopes of the basin of Big River, which is a tributary of the Kuskokwim lying outside of the area described in this report, but no details as to their extent or character have been published.

WATER RESOURCES.

As yet almost none of the available water powers of the Lake Clark-Iditarod region have been put to use. In large measure this neglect is due to the small demand for power, except in the mining camps, for the Iliamna-Lake Clark region contains probably some of the best water powers in Alaska. The future use of the now undeveloped water powers depends on their availability, which in turn

[1] Buckman, W. L., unpublished letter.



LEGEND

QUATERNARY

Unconsolidated gravels, sands, and silts
(Of glacial, fluvial, lacustral, and marine origin)

QUATERNARY AND LATE TERTIARY

Lavas and volcanic fragmental material
(Comparatively undeformed)

EARLY TERTIARY

Sandstones and shales, chiefly of fresh-water origin
(Coalbearing in part. More or less deformed)

LATE MESOZOIC OR EARLY TERTIARY

Intrusives, chiefly of siliceous granitic character
(Cutting Mesozoic and Paleozoic rocks in the form of masses and dikes. The primary mineralizing agency of the region.)

MESOZOIC

Sandstones, shales, and conglomerates; chiefly marine, but fresh water in part
(Also some porphyries and tuffs in Iliamna district. Highly deformed but unmetamorphosed except by contact alteration by intrusives)

PALEOZOIC AND POSSIBLY OLDER

Schists, slates, crystalline limestones, and ancient volcanic flow and fragmental rocks
(Highly deformed and more or less regionally metamorphosed)

× Gold placer

Gold lode

Copper

Cinnabar

Coal

Petroleum

slack
is do
A
giver
easily
disco
mally
Creta
anthr
subje
Co
neigh
the I
north
done
been
Nor
that h
place,
out, h
factor
dred
Coa
at two
the he
stream
discov
[Holit
will in
Coal
flanks
of Big
of the
or cha

As y
Clark-
neglect
camps,
of the
develo

depends on the purposes for which they are to be employed and their cost relative to other sources of power. So many factors interact in relation to this matter and interact in so complex a manner that their evaluation can be effected only by analyzing a specific problem.

The general areas where mineral deposits may be sought with some assurance of success, as has already been pointed out, are those where intrusive masses cut the country rock and have brought in mineralizing solutions. Areas of this sort are scattered here and there throughout the Lake Clark-Iditarod region, but most of them are of small size and the harder igneous rocks form the higher parts of the upland. Consequently the mineralized areas in most places are drained by small headwater streams, which in their upper parts have exceedingly steep gradients and little volume. Under these conditions a water supply adequate for large-scale mining usually can not be found close at hand. In many places probably small mining plants can acquire sufficient water by building short ditch lines, but many of them will undoubtedly experience the same difficulty as has been felt by those situated in the mineralized area at the head of Flat Creek, where, when rain is not falling, the water supply is inadequate. Recourse to long ditch lines, such as have been built in Seward Peninsula to overcome the difficulties of a region topographically similar, may, of course, be feasible. Long ditch lines, however, are expensive, and their construction should not be advocated until their lines have been carefully surveyed, the volume of the supply they tap accurately determined, their installation critically investigated, and the mineral deposit to which they are planned to bring water proved to contain sufficient valuable minerals to defray their cost.

For agriculture the water supply would seem to be sufficient, even if a considerable part of the country should ultimately prove to be adapted to cultivation. In fact, one of the problems would probably be to drain the area rather than to bring additional water to it.

No hot or thermal springs have been reported to occur in the region, and the general geologic conditions indicate that they are not likely to be found except under special conditions.

QUICKSILVER DEPOSITS OF THE KUSKOKWIM REGION.

By PHILIP S. SMITH and A. G. MADDREN.

INTRODUCTION.

The central Kuskokwim region is the only portion of Alaska where up to the present time lode prospects of quicksilver that have attracted serious attention have been discovered. Minerals carrying this metal, however, have been noted in the gold-bearing gravels of several placer-mining districts of Alaska. For example, mercury minerals have been found in the concentrates of sluice boxes from placer claims in Seward Peninsula on Daniel, Iron, and Ophir creeks; in the Iditarod district on Happy, Black, and Glen gulches; and in the Yukon-Tanana region on Seventymile Creek. In none of these places, however, have commercial amounts of these minerals been discovered.

At two localities on the Kuskokwim considerable interest has been shown recently in lode prospects of quicksilver. One of these, the Parks prospect, is in the central part of the Kuskokwim basin, and the other is near Kolmakof, about 100 miles downstream from the Parks prospect. (See Pl. X.) The observations at the Parks prospect were made by Philip S. Smith, and those at the prospect near Kolmakof were made by A. G. Maddren.

The investigations of the quicksilver deposits were made in the course of general surveys of the Kuskokwim and adjacent regions in the summer of 1914. Descriptions of the results of these general surveys are printed elsewhere in this volume[1] or are in preparation, and should be consulted by those desiring information concerning the broader features of the geology and geography of the part of Alaska in which the quicksilver deposits occur.

HISTORICAL SKETCH.

Possibly the earliest published reference to the occurrence of quicksilver in Alaska was made by Dall,[2] who stated: "Mercury, in the form of cinnabar, exists in the Cretaceous strata of the Alex-

[1] Smith, P. S., Mineral resources of the Lake Clark-Iditarod region, pp. 247–271. Maddren, A. G., Gold placers of the lower Kuskokwim, with a note on copper in the Russian Mountains, pp. 202–360.

[2] Dall, W. H., Alaska and its resources, p. 477, 1870.

ander Archipelago. The locality is unknown, but fine specimens were in the possession of the Russians." So far as now known, however, cinnabar has never been found in any part of southeastern Alaska. The locality from which the quicksilver specimens came was therefore stated incorrectly to Dall by the Russians (presumably at Sitka), possibly because they did not wish to arouse in the newcomers interest in the remote part of the Territory. Apparently the Russians were disinclined to impart accurate information, for some of the United States officials who visited Sitka about the time of the transfer of the Territory to the United States reported that the Russians furnished very vague and indefinite data concerning the source of mineral specimens in their possession and the location of reported mineral deposits.

Petrof[1] appears to have first recorded the occurrence of quicksilver in Alaska in a region where its presence has been authenticated. He states that in the Kuskokwim region are—

> well-defined veins of cinnabar, antimony, and silver-bearing quartz. * * * Cinnabar has also been discovered on the Kuskokwim, and assays made of the ore in San Francisco indicate a very valuable discovery there. * * * The mountains eastward of the Rédoute Kalmakovsky are high, heavily timbered around the base, and give ample evidence of the presence of mineral deposits, veins of quartz, cinnabar, and other ores being easily traced wherever the slopes and bluffs are exposed to view.

Ten years later, in the report of the Eleventh Census,[2] the following general statement, which contains little new information, was made concerning the occurrence of cinnabar in Kuskokwim Valley:

> Veins of cinnabar crop out at various points along the river, but though they are known to contain a large percentage of mercury, their remoteness from shipping has thus far prevented their thorough examination or development.

Spurr,[3] who visited the region in 1898, reports as follows:

> About 5 miles below Kolmakof, in a cliff on the right side of the river, a trader, Mr. Lind, found, several years ago, a vein of cinnabar, or ore of mercury, which has been mentioned in numerous reports of Alaskan governors and other publications. The vein occurs in a locality where the stratified shales of the Kolmakof [Upper Cretaceous] series are cut by frequent dikes of siliceous yellow-weathering rock. According to Mr. Lind, the vein is an impregnation of the arkose and other sedimentary beds with red cinnabar, the mineralized rock taking the form of a vertical zone a foot or two wide, often irregular and pinching out. Mr. Lind spent about $2,000 in mining some of the ore and getting it to the States, but on account of the small quantity and the low price of mercury, he lost on the venture.

[1] Petrof, Ivan, Report on the population, industries, and resources of Alaska, pp. 13, 77, 90, 1884.

[2] Report on the mineral industries of the United States at the Eleventh Census, 1890, p. 106.

[3] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, p. 261, 1900.

The references to cinnabar in the reports of Alaskan governors[1] noted above by Spurr are simply brief repetitions of the general information published in the census reports of 1880 and 1890, already quoted.

Spurr does not appear to have observed the outcrop or excavations from which the ore shipped by Mr. Lind was taken, although he notes the sedimentary rocks and describes a dike which is only about 200 feet downstream from the prospect. Apparently in 1898 artificial excavations along the bluffs were not large enough to attract attention to the spot where the cinnabar occurs, so that Spurr learned of the deposit only after arriving at Bethel, about a week later. At this place he seems to have met Mr. Lind and to have been informed by him of the facts quoted above. Spurr's failure to see the excavations is not surprising, however, for in 1914, even with the aid of persons familiar with the locality, Mr. Maddren found the indications of cinnabar obscure, in spite of the fact that further work is reported to have been done on this prospect within the last ten years.

DESCRIPTIONS OF PROSPECTS.

PARKS PROSPECT.

LOCATION AND DEVELOPMENTS.

The only place where any considerable amount of development work has been done on quicksilver lodes is at the Parks prospect, on the north bank of the Kuskokwim, about 15 miles above Georgetown by river, or about 330 miles above the mouth of the Kuskokwim. It is readily accessible, for the main workings are situated not more than 100 feet from the river and about 15 feet above it.

Quicksilver ore was discovered at this place about eight years ago (1906), and development work has been done on a small scale ever since. At no time, however, have more than two or three men been employed on the property, and this small force, with insufficient funds, has succeeded in opening the deposit only slightly. A small portable retort has been used in reducing the ore, and by means of it about 700 pounds of quicksilver has been produced. This has been sold to the placer miners in Seward Peninsula and in the vicinity of the prospect. By the crude process employed only about 4 pounds of ore can be treated at a time, so that the reduction of the ore has been slow and costly.

The ore occurs along the bank of the stream and has been followed in these natural exposures for a few hundred feet. The main development has been the driving of a crosscut adit about 200 feet long

[1] Swineford, A. P., Report of the governor of Alaska for the fiscal year 1886, p. 949; idem for the fiscal year 1888, p. 18. Knapp, L. E., idem for the fiscal year 1891, p. 31.

across the general strike of the shales and sandstones that form the country rock. The rocks stand well, so that almost no timber is used except in the fractured and disintegrated surface zone near the entrance of the adit. Several prospect holes and shafts, the deepest of which is said to be about 45 feet, have been sunk farther up the slope. Most of these old pits have been lying idle so long that they are now filled with water and are not accessible. Considering the length of time that the deposit has been known, only a small amount of development has been accomplished, and that has not been planned so as to disclose most effectively the characteristics of the deposit.

The slope of the adit affords a grade sufficient to carry off the water from the underground workings and to aid the tramming out of ore and waste. The back of ore above the adit level, however, is not great, and consequently if the property is developed power for pumping and hoisting must be provided. An attempt has been made to prepare for the installation of a modern furnace for reducing the ore, but lack of funds has allowed little to be done except the clearing of a site on the hillside near the crosscut adit. The installation of a furnace is hampered not only by lack of funds, but also by the lack of easily accessible material suitable for the construction. The sandstones and shales of the neighborhood are not strong enough for walls and supports, so that even the rougher construction materials must be transported several miles, and the special material, such as fire brick, must be brought all the way from the States. A fairly resistant igneous rock occurs a short distance downstream from the site selected for the furnace, but it is not abundant, and probably the nearest place where a strong, durable rock can be obtained is Barometer Mountain, about 5 miles south of the prospect.

GEOLOGIC OCCURRENCE.

The country rock in the vicinity of the prospect consists of sandstones and shales of Cretaceous age. The sandstones are rather fine grained and appear to contain no pebbly phases. Most of the grains are angular and consist of fragments of rather fresh dark iron silicates and quartz. Some of the sandstones contain a number or worn mica flakes which have evidently been derived from the now buried metamorphic or igneous rocks of older age. The shales are black and are so fine grained that the individual particles are not recognizable by the unaided eye. Near the mineralized areas these rocks are considerably shattered and in places much slickensided. The rupturing does not appear to be widespread, and a short distance from the claims the normal unshattered condition of the rocks prevails.

Igneous rocks of two distinctly different kinds have been recognized. One of these, a gray-green medium fine grained rock with prominent flakes of biotite over a quarter of an inch in diameter, is closely comparable with diabase, and the other, a light-gray, nearly white rock, belongs to the group of granitic rocks. The rock resembling diabase occurs as a poorly exposed, slightly inclined thin layer at some distance from the ore bodies. Its relations to the other rocks are not clearly shown, but apparently it is later than the shales and sandstones and occurs as a sill rather than as a flow interstratified with the sediments. When examined microscopically the rock is seen to be composed mainly of small laths of feldspar and large flakes of biotite. The feldspar is not excessively twinned, usually only twice, and is little decomposed, and the larger part of it has been determined to be labradorite. The biotite is in blades which are little decomposed and which show strong absorption in polarized light. Considerable chlorite is scattered irregularly through the thin section and apparently has been derived principally from the decomposition of ferromagnesian minerals. No undecomposed iron silicate minerals were recognized, but blades and fragments of altered minerals that, from their apparent original rectangular cleavage, are believed to have been augite are fairly common. The relations are not definitely proved, but this rock is believed to be older than the granitic rock.

The best exposures of the granitic rock are afforded in the crosscut adit. In this adit, beginning at the entrance and extending in a northeasterly direction toward the face, is a succession of sedimentary rocks having a low northeasterly dip, which increases toward the northeast. These sediments are cut, about 75 feet from the entrance of the adit, by a 3-foot dike of the light-colored igneous rock. Succeeding the dike is an area of much shattered and brecciated dark slates. The shattering is so thorough, though apparently on a small scale, that within short distances trends toward almost all points of the compass may be found. Although the strike of these rocks is not constant, the dip is in general so steep as to be practically vertical. Many stringers of quartz have been formed in the open spaces produced by this brecciation, and most of the ore minerals have been introduced into this zone. Beyond it the sediments are followed by more of the granitic igneous rock. This extends uninterruptedly for about 100 feet, to a point where more shattered shale was found. The contact between the shale and igneous rock was followed for about 30 feet, until the fact became apparent that the adit was curving backward so that it was only a few feet from the point where the deflection to the northwest had been made. The general conditions at this place are represented in

figure 7, which shows the geology as exposed in this opening. The amount of exploration has not been sufficient to determine the shape or size of the igneous masses, but judged from surface indications they are not large, and they appear to be more or less cylindrical bodies rather than extensive plugs or batholiths.

When examined under the microscope the igneous rock is seen to be so much decomposed that few of the original minerals are preserved. The small amount of quartz in the decomposed rock indicates that little of this mineral was originally present. Carbonate occurs in the rock in considerable quantities as a secondary mineral. In some of this secondary carbonate small patches of cinnabar have been recognized. Sericite is a common secondary mineral. The rock is usually much stained with iron hydroxides.

At a prospect pit a few hundred feet from the main adit described above is an exposure of a light-colored igneous rock which probably belongs to the same period of intrusion as the igneous rock in the adit. It is, however, less weathered, and a microscopic examination of specimens from this place showed a porphyritic rock whose phenocrysts are quartz and completely altered feldspar. The feldspar had been altered to quartz, sericite, and a fine-grained indeterminate material. The groundmass is a fine-grained mixture of primary quartz and secondary products which doubtless had been derived from the decomposition of the original feldspars. In all probability the rock was an acidic porphyry, probably of rhyolitic or latitic composition. The porphyritic rock is much more quartzose than the decomposed rock found in the adit. The field occurrence, however, seems to point clearly to the close association of the two rocks, and therefore, although the rock from the adit appears to be much more basic, it probably is equivalent to the porphyritic rock from the prospect pit, and both are regarded as granitic or monzonitic porphyries.

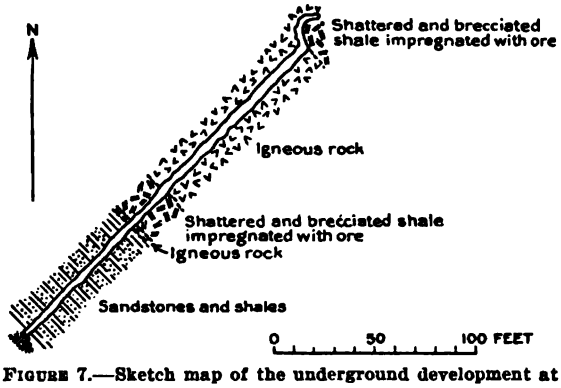


FIGURE 7.—Sketch map of the underground development at Parks quicksilver prospect.

The main occurrence of the ore is in the brecciated zone adjacent to the contacts of the igneous masses. Wherever this zone is found some mineralization has occurred. This shattered condition close to the igneous rocks is not limited to a single dike or stock but seems

to be general wherever the sediments have been cut by intrusives. Where there are several dikes whose margins are mineralized exaggerated estimates of the possible future tonnage of the property are likely to be made if the true geologic structure and relations are not ascertained. This can be done only by careful prospecting by experienced men, but until development work of this sort has been done, the value of the property can not be determined.

Although the distribution and direction of the deposit have not been definitely determined, the dikes and igneous bodies seem to trend, in general, northwest, and this is probably the direction of their greatest horizontal extent. Some evidence in support of this view is afforded by the material in the creek several hundred feet west of the adit, about 50 feet from the Kuskokwim. This material is mainly ore, as if a highly mineralized lead were cut by the creek at this point. A notable feature of the unconsolidated material in this stream is the amount of native quicksilver it contains. The material in the bed of the creek, which is little more than a wet-weather stream, consists mainly of angular frost-riven fragments apparently derived from a near-by bedrock source. Pans of this slightly water-sorted material yielded so much quicksilver that perhaps half a spoonful was obtained from three moderate-sized pans. The origin of the native quicksilver was not determined definitely, but probably it was produced by the natural reduction of the cinnabar. This reduction may possibly have been assisted by the heat of former woods fires. The hillsides near the prospect have been recently burnt over, as is shown by blackened vegetation and standing fire-scarred trees, and other fires doubtless occurred in the past. The amount and distribution of the native quicksilver seem to preclude the possibility that it has been inadvertently spilled or has been lost in earlier operations. Native quicksilver, either as a primary constituent or as an alteration product, has been frequently reported to occur in cinnabar lodes, but it has seldom been reported to occur upon the present surface, as at the Parks prospect.

CHARACTER AND RELATION OF MINERALIZATION.

The mineralization is closely related to the shattered and brecciated contact zone between the igneous dikes and the sediments. The metallic minerals are almost exclusively cinnabar and stibnite. Iron pyrite in narrow stringers, most of them less than one-eighth of an inch wide, has been seen at a few places, but almost nowhere is it intermixed with other sulphides. In fact, it is so distinct that the impression gained in the field was that it had been introduced at an entirely different time than the ore minerals. Subsequent study in the

laboratory, although affording no evidence in support of this view, has shown no facts that are opposed to it.

In few places is a distinct veinlike form recognizable in the deposit. On the river bank a little west of the main opening a veinlike mass about a foot wide showing a somewhat banded structure has been traced for a short distance. Normally, however, the mineralization follows the irregular partings between the shattered fragments of country rock, and consequently forms a network of anastomosing stringers and lenses.

The ore near the surface is weathered to a rusty brown iron-stained color. In the more oxidized portions of the deposit the cinnabar is practically unrecognizable by inspection of the fragments, owing to the coating of iron oxides. In less decomposed parts the characteristic red of the cinnabar becomes more evident, until in the unaltered parts the blood-red cinnabar is very striking.

The cinnabar occurs principally in small particles intimately mixed with the well-formed crystal blades of stibnite, the sulphide of antimony. These two minerals were deposited almost contemporaneously, for the stibnite incloses and is inclosed by the cinnabar. So closely do the two minerals occur together that the mineral livingstonite—the sulphide of antimony and mercury—was reported to be the metallic sulphide other than cinnabar occurring in this deposit. Tests by R. C. Wells, of the chemical laboratory of the Geological Survey, failed to find this mineral and instead proved that the supposed quicksilver content of the stibnite was really derived from the minute particles of cinnabar that were intimately intergrown with the stibnite.

Tests were also made by Mr. Wells to determine whether any of the compounds of selenium or tellurium and mercury were present. Neither selenium nor tellurium was found in analyses of bulk samples, and therefore the compounds of mercury and these elements must also be absent.

The stibnite occurs usually in distinct crystals, which in places are so closely intergrown that their boundaries are those impressed upon them by the other particles with which they are in contact and are not the normal crystallographic faces. In places, however, where room was available for the crystals to form—as, for instance, in the vicinity of the vugs—the stibnite is in its characteristic bladed form with shining cleavage planes. Some of the crystals of stibnite are an inch long and a quarter of an inch wide, but most of them are smaller and range in size down to hairlike radiating aggregates so minute that the crystal faces can not be recognized by the aid of a hand lens. In most of the specimens collected the stibnite occurs in considerably greater amounts than the cinnabar.

The character and amount of gangue that accompanies the ore differ notably in different parts of the exposures. In places the sulphides are practically the only minerals in the deposits. Usually, however, considerable quartz and carbonate accompany the ore minerals. The carbonate consists of siderite or ferruginous dolomite and usually occurs in crystalline masses. Clearly in one specimen and apparently in others the carbonate has been traversed by narrow quartz stringers, associated with which are the bulk of the metallic minerals. The quartz in these narrow stringers near the contact with the carbonate is almost opaline, but farther away it is more crystalline, and in places where vugs have been formed small, perfectly terminated quartz crystals project into the cavities. In some of the vugs perfectly formed crystals of cinnabar have grown on the crystalline quartz.

In thus calling attention to a paragenetic arrangement that has been observed in some of the specimens the impression should not be gained that the ore is characterized by a well-marked banded appearance. Instead all the minerals were deposited so nearly at the same time that even the carbonate, which appears in places to be one of the earliest minerals formed, contains inclusions of the cinnabar, which appears usually to be one of the later minerals.

PROSPECT NEAR KOLMAKOF.

LOCATION AND GENERAL TOPOGRAPHY.

A quicksilver deposit has been opened in the bluff on the north bank of Kuskokwim River, about 5 miles downstream (west) from the trading post of Kolmakof. This settlement is on the south bank of the main river about 160 miles above Bethel, a port for small seagoing vessels on the tidal portion of the lower river about 150 miles from Goodnews Bay, on Bering Sea.

The principal topographic features in the vicinity of Kolmakof are a broad alluvial lowland that forms the flood plain of a somewhat older wide valley, about 50 feet below which lie the present flood plain and channel of the Kuskokwim; a wide belt of moderately mountainous highland north of the river, with a generally rolling surface from 1,000 to 2,000 feet above sea level, diversified by the deeply eroded valleys of the larger tributary streams and many gulchlike valleys of lesser extent eroded by the smaller streams; and an isolated group of rather rugged mountains, locally known as the Russian Mountains, that rise prominently above the adjacent highlands to altitudes of 4,000 to 4,500 feet above sea level.

Near Kolmakof the Kuskokwim has an average width of about two-thirds of a mile, and its channel is practically unobstructed, only one or two alluvial islands overgrown with willows being

present near its south bank. Downstream throughout its course from a point about 10 miles above Kolmakof the south bank of the Kuskokwim is composed of unconsolidated silts, sands, and gravels without any outcrops of hard bedrock. In this part the river flows alternately along sections of gently sloping bank bordered by sand and mud bars in shoal water and sections where the water is deeper and the current stronger, so that it cuts rapidly into the unconsolidated sediments and undermines them, forming steep slopes that rise from 10 to 25 feet above the water. At a few widely separated places the bluffs rise to heights of 40 or 50 feet above the river. Kolmakof immediately overlooks the river on one of the most prominent of these higher bluffs.

The north bank of the river is made up chiefly of rock bluffs from 100 to 400 feet high, interrupted at widely separated intervals by small isolated lowland areas of unconsolidated sediments. Narrow alluvial benches fringe the base of some of the rocky bluffs for short distances, but the river at flood stages flows at the foot of most of the bluffs, so that they are kept bare by the removal of the disintegrated talus, which makes a considerable part of the slopes above high-water mark. None of the bluffs along this section of the river are so abrupt as to hinder free passage on foot along their bases at ordinary stages of the river.

Kolmakof River, a considerable stream, enters the Kuskokwim from the northeast a mile below Kolmakof. About 20 miles farther down a somewhat larger stream, Owhat River, joins the Kuskokwim from the north. These two streams border the rugged Russian Mountains on the east and west, respectively. The tract between them is dissected into a number of broad rolling ridges and subordinate spurs by steeply incised valleys drained by creeks that flow southward into the Kuskokwim. The Kuskokwim has truncated the south ends of these ridges and formed a series of rock-cut bluffs. These bluffs, which start at a point about 4 miles below Kolmakof, are prominently developed for a distance of about 12 miles. In general, the profile of each major bluff section presents a gradual ascent from one tributary valley to a maximum height along the crest in the central part and an equally gradual descent to the succeeding valley.

GENERAL GEOLOGY.

In the vicinity of Kolmakof the hard-rock bluffs are made up principally of a widespread series of sedimentary rocks of considerable thickness which have been intruded by dikes and sills of both acidic and basic composition. Large masses of igneous rocks of granitic and porphyritic texture which seem to be of more deep-seated origin and which mark centers of laccolithic or batholithic

intrusion occur in the higher isolated mountain groups, such as the Russian Mountains. Probably many of the small dikes and sills intruded into the sediments are offshoots of the larger masses of intrusive rocks of deep-seated origin. This relation, however, has not yet been definitely proved.

The sedimentary rocks are composed of alternating beds of sandstones and shales, most of which are from a few inches to about a foot thick. Some of these beds grade from sandy to shaly texture within short distances along their bedding, and at various horizons both sandy and shaly members show ripple markings or similar indications of deposition in shallow water. Some of the sandstones, however, have a thickness of 100 to 200 feet, and some of the shales are 200 to 400 feet thick. These heavier members appear to be developed at several different horizons in the series. The thin-bedded sandstones and shales aggregate at least 4,000 to 5,000 feet in thickness and form most of the exposures in the river bluffs. No marked lithologic differences were noted in the section except toward the top, where somewhat coarser textured arkosic sandstones of lighter color are developed in place of the finer-grained, more dense dark-gray quartzose sandstones that characterize the stratigraphically lower part of the series. Many of the shale members are slightly calcareous, but none are calcareous enough to be properly called limestone. All the shales are dark colored. Many of the nearly black shales are somewhat carbonaceous.

The quartzose sandstones are dominantly dark gray, fine to medium grained, and of dense texture. Some of these beds, however, contain coarse material and discontinuous layers of grit. No conglomerate was seen within the bulk of the sediments, although at or near the base of the series in adjacent areas heavy beds of this rock occur. Some of the sandstones, like certain of the shales, are slightly calcareous.

The arkosic sandstones are distinguishable from the quartzose sandstones chiefly by their lighter color, coarser grain, and heavier bedding. They also differ from the darker and denser sandstones in that they contain numerous scales of light-colored mica which may be easily recognized by the unaided eye. These arkosic sediments where unweathered are usually light gray; in weathered outcrops, however, they usually have pale-yellowish tints, and near the intrusive igneous contacts they are commonly light purplish or iron-rust brown.

At least 1,000 feet of these beds is exposed in the bluffs in which the cinnabar prospect near Kolmakof occurs. Fully as great thicknesses of sediments of the same general character are exposed in sections which may or may not be duplications, in part. at least, of the others. Therefore the total thickness of the sedimentary series is probably very great.

CHARACTER AND RELATION OF MINERALIZATION.

The details of the bluff in which the cinnabar mineralization occurs are shown in figure 8. At this place the bluff rises about 200 feet above the river. Few outcrops of bedrock are exposed along the upper portion of the bluff, except here and there where fresh slides have occurred. Most of the upper slope is covered by more or less unstable slide rock and loose soil, matted together by the roots of a close growth of brush and a considerable number of spruce and birch trees. Even where the rocks are exposed they are so deeply shattered and disturbed by surface creep that little can be determined about their structure and relations.

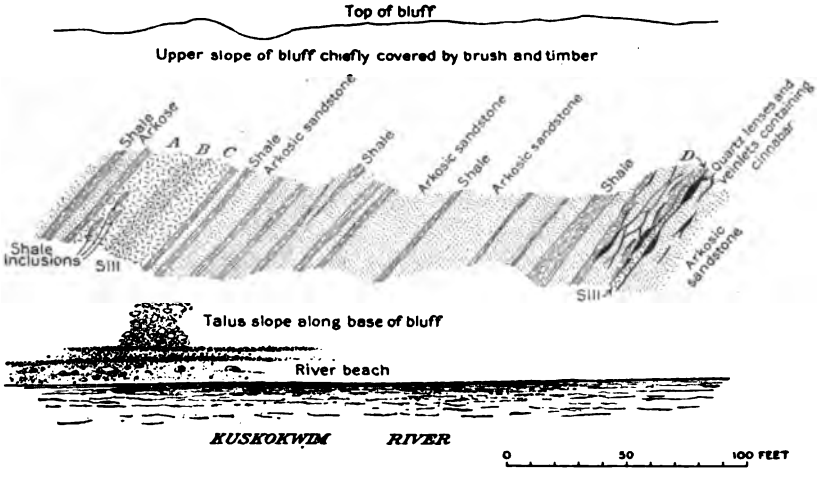


FIGURE 8.—Generalized section of bluff on Kuskokwim River about 5 miles below Kolmakof.

Usually the best exposures of undisturbed bedrock are found in a narrow strip 20 to 100 feet above the river, but even these are considerably obscured by disintegrated material and interrupted by gullies filled with slide rock. The country rocks at the prospect are interbedded arkose and shale. Several of the arkose beds are as much as 20 feet thick, but on the average they are considerably thinner. The shale beds range from thin layers to beds 2 or 3 feet thick. Rocks of this kind occupy a belt 3 or 4 miles wide along the river, but their northward extension is obscured by the covering of soil and vegetation. Sedimentary rocks of the same character are reported on the upper part of Kolmakof River, about 20 miles above its mouth, and probably they have a widespread distribution throughout the mountainous highland.

The beds of this belt of arkosic sediments strike N. 30°–80° E. Their dip changes along the different folds from southeast to north-

west. At the quicksilver prospect (fig. 8) the rocks strike N. 60°–70° E. and dip 40°–50° NW.

For several miles upstream from the quicksilver prospect no intrusive rocks were seen cutting the sediments, but downstream from the prospect sills and dikes are numerous. Most of the intrusive masses are sills—that is, the molten igneous rock has been injected along the bedding planes of the sediments, rather than across the beds in the form of dikes. However, some of the intrusive sills follow one bedding plane for a distance and then cut across a few feet of beds to another bedding plane and follow it. Fragments of the country rock are included in both the sills and the dikes.

Two sills of igneous rock appear to have been the primary factors in the mineralization at the quicksilver prospect. The relations of these sills are shown in figure 8. The sills are about 200 feet apart. The larger sill, which is about 30 feet thick, is divisible into three parallel zones, marked *A*, *B*, and *C* in figure 8, and the smaller sill, which is 1 to 2 feet thick, is marked *D*. Apparently the larger sill is the one which Spurr[1] particularly noted and described as bostonite.

Four representative specimens collected from these different parts have been examined microscopically by J. B. Mertie, of the Geological Survey. The rock of zone *A* is an altered pyroxene andesite, composed of acidic plagioclase, much altered; a completely calcitized mineral, probably originally pyroxene; iron oxides, altered largely to limonitic material; apatite; calcite as secondary material, with cinnabar intimately associated; minute dark particles, also associated with the calcite and distributed throughout the rock; and pyrite, associated with a black opaque material. The general color of the rock from zone *A* is pale gray, with iron-rust tints along the fracture planes and darker purplish tints on the surfaces that have been most exposed to weathering. Cinnabar in the form of small red crystalline particles gives a faint pink tint to the calcite, with which it is intimately associated. The calcite occurs in minute gash veins, rarely more than one-twentieth of an inch thick or an inch long, distributed throughout the rock along irregular fractures and in small vuglike cavities. The cinnabar, which may be distinctly seen with a hand lens, is embedded in or intergrown with the calcite of the veinlets and incrusts the surfaces of the small cavities.

The rock in zone *B* is readily distinguishable from that in the other zones by its much darker gray color, fresher appearance, and greater hardness. These differences, however, may be due to differences in the amount of leaching that has occurred in the central and outer zones. The rock in zone *B* proves to be a pyroxene andesite, practically the same as that of zone *A*. It is composed of acidic

[1] Spurr, J. E., A reconnaissance in southwestern Alaska in 1898: U. S. Geol. Survey Twentieth Ann. Rept., pt. 7, pp. 129, 216, 1900.

plagioclase, much altered; an altered mineral, apparently pyroxene; hornblende, more or less altered; biotite; olivine in small amount; iron oxides, largely altered to limonite; apatite; calcite, as secondary material, replacing rock minerals; and quartz, probably chiefly secondary. No cinnabar was recognized in zone *B*.

The rock of zone *C* is an altered hornblende andesite, that contains acidic plagioclase, much altered; possibly some altered pyroxene; hornblende in various stages of alteration; biotite; iron oxides, largely altered to limonitic material; apatite; calcite and zeolite, as secondary minerals; quartz, probably chiefly secondary; and pyrite, associated with a black opaque substance. Cinnabar appears to be absent. This rock is light gray, like that from zone *A*, and has along its joints and on exposed surfaces iron-rust stains, which impart to it a somewhat yellowish color.

The cinnabar mineralization appears to be confined to zone *A*, which contains the inclusions of shale country rock and occupies the hanging-wall side of the sill. Whether or not the carbon of the shale inclusions in zone *A* had a special influence upon the segregation of the cinnabar in this portion of the sill is not definitely known, though probably it did.

The smaller sill (*D*, fig. 8) appears to be the more important with regard to quicksilver mineralization and is near the place where most of the quicksilver ore has been obtained. This sill is an altered hornblende andesite, similar in composition to that of zone *C* in the larger sill. Its mineral constituents are acidic plagioclase, much altered; some completely altered minerals, probably for the most part originally hornblende, with some pyroxene; iron oxides, altered to limonitic material; apatite, unaltered; calcite, replacing rock minerals and in veinlets, associated with pyrite; quartz, probably chiefly secondary, in places associated with pyrite; and pyrite, intergrown with a black, opaque substance of unknown composition, which may be an alteration product of the pyrite or some other sulphide, possibly metacinnabarite, intergrown with the pyrite. This rock is light gray within, purplish iron-stained to a depth of an inch in the marginal portions of the irregularly fractured blocks, and bright rusty iron-stained along the less exposed joint planes.

No cinnabar was noted in the igneous rock of the smaller sill itself, but appreciable amounts occur in lenses and stringers of quartz near the sill and extend along joint and bedding planes of the adjacent sediments. The maximum width of the mineralization, including the sill, which is 1 to 2 feet wide, appears to be about 4 feet in the small part of the outcrop that is undisturbed by creep. The cinnabar-bearing quartz lenses are neither large nor numerous in the present exposure. Few of them are more than 6 inches thick or more

than 2 feet long. The cinnabar is distributed irregularly and is roughly interbanded with quartz. The thickest band of fairly pure, more or less crystalline cinnabar observed was about a quarter of an inch wide. Practically all the cinnabar appears to be in the quartz lenses and stringers, although probably minor amounts also occur in the shattered sedimentary rocks between the two sills. Although the sediments on each side of the sills are probably impregnated with cinnabar in appreciable amounts, it is not likely that quicksilver ore of commercial grade occurs outside of the narrow area in immediate association with the smaller sill which is occupied by the quartz lenses. The amount of ore in this zone does not seem to be sufficient to be profitably exploited under the present conditions of the region. Intelligently directed development of this prospect, however, might possibly disclose larger ore bodies. No work was in progress at this prospect at the time of the writer's visit, and nothing was seen that showed that the deposit had ever been extensively developed. Only superficial excavations have been made from time to time at various points along the outcrop, and no attempts appear to have been made to trace the extent of the mineralization back from the crest of the bluff.

MISCELLANEOUS LOCALITIES.

Several claims have been staked in the vicinity of the Parks prospect, and explorations on a small scale have been made at these places. Willis & Fuller have been doing some work on the divide between Kuskokwim and George rivers, about 2½ miles northwest of the Parks property. Some quicksilver ore has been found, but the development has not been carried much farther than that required by law to hold the property. The geologic conditions in general are the same as at the Parks prospect and at the prospect near Kolmakof. Dikes of light-colored intrusive rock cut the sandstone and shale country rocks, and in the vicinity of the contacts mineralization has taken place.

Cinnabar has been found in the residual placer material in the areas of intrusive rock near Iditarod. Very little cinnabar has been observed with quartz in place, but angular fragments of vein matter that without doubt have been derived directly from joint fillings in the granitic rocks contain cinnabar. Fragments of this kind are commonly found in residual material in Happy and Black gulches. In the deposits, especially in Black Gulch, small subangular pebbles and grains of cinnabar, obviously derived from quartz veinlets, accumulate in appreciable amounts as concentrates in the sluice boxes. From 500 to 1,000 pounds of cinnabar pebbles are said to collect in an ordinary string of sluice boxes during 3 or 4 days of shoveling-in operations.

Though cinnabar occurs with quartz in some of the small veins that occupy joint cracks, it also occurs in subordinate association with stibnite. In these veins the cinnabar appears normally in the more quartzose portions of the stibnite bodies. Several small veins of this kind have been observed on the lower part of Glen Gulch. In these veins stibnite is the most abundant metallic mineral, and the cinnabar occurs as flakes and blebs associated with quartz. The stibnite-cinnabar mineralization seems to be confined to the stronger quartz stringers that are deposited here and there within the granitic rocks and to the stronger zones of small extent in the altered sediments at or near their contact with the intrusives. One of these zones of stibnite-cinnabar mineralization, several feet wide but not very long, occurs in slaty rocks along the contact at the head of Glen Gulch. Some open-cut work was done to prospect this area, but it was soon abandoned because the metallic minerals were found to occur in rather disconnected lenses and vugs with a large percentage of barren vein quartz, so that the deposit as a whole did not appear profitable under present conditions.

ORIGIN AND PROBABLE EXTENT.

In discussing the general views held as to the origin of the quicksilver deposits of the world, Lindgren[1] states:

> When it is noted that hot springs and volcanic surface flows are present in almost all regions of importance (except Almaden in Spain, Idria in Austria, and Nikitowka in Russia) and that cinnabar in considerable quantities is associated with undoubted spring deposits or is actually deposited in hot springs, the argument becomes very strong indeed that such hot springs have formed the majority of the deposits. For the few deposits that have no such clear connection with volcanic rocks for instance, those mentioned above the characteristic mineral association still holds good, and we are forced to the hypothesis that volcanism and hot-spring action are the causes of these also, though the products of the igneous activity may have failed to reach the surface and the hot springs may have subsided.

In other parts of the book cited, as well as in many of his other writings, Lindgren has clearly shown that he does not confine the term "hot springs" to those deriving their water from the surface but includes those that derive their water from hot ascending solutions, possibly of magmatic origin. If the term is used in this broad sense, the quicksilver deposits here described may appropriately be called hot-spring deposits. They are evidently closely associated with the igneous rocks and have derived their mineral content from the emanations of the intrusive masses in the form of solutions.

To judge from the geologic occurrence of the ores, the depth at which they were formed apparently was not great. This conclusion

[1] Lindgren, Waldemar, Mineral deposits, pp. 469–470, 1913.

is supported by the number of open spaces that are still preserved and the number of open spaces that were in existence when the mineralization took place but are now filled with ore and gangue. It is further supported by the shattered condition of the rock adjacent to the intrusions, for the shattering probably could have taken place only under slight load, such as is characteristic of the surficial part of the earth's crust.

The significance of the determination of the depth at which the mineralization took place is that it gives an indication as to the probable extent of the deposit, both vertically and horizontally. If the deposit was formed near the surface it probably, like the California deposits, decreases in tenor with increase in depth. In the California deposits practically no workable ore extends to a depth of more than 1,000 feet. Furthermore, the shattering of the country rock adjacent to the igneous intrusives formed an easily pervious zone, so that the mineralization would tend to be limited to this zone and not diffuse far into the unshattered rock. This shattered zone, so far as is now known, does not extend far from the intrusive rock; therefore mineralization is not to be expected far from the dikes. If the dikes are numerous the shattered rock may furnish sufficient space for the accumulation of considerable ore, but as a rule the zone surrounding a single dike does not exceed a few feet.

At Barometer Mountain, a few miles south of the Parks prospect, and at the Russian Mountains, north of the Kolmakof prospect, considerable masses of intrusive granitic rock are exposed. Possibly similar intrusive rocks also occur near the prospects but at so great a depth that only the apophyses from them are exposed at the surface. These apophyses may be represented by the dikes of intrusive rock near the ore bodies. If this interpretation is correct, probably in the deeper parts near the larger masses the country rock is not so much fractured and spaces for the deposition of the ore are not so numerous. Furthermore, at the higher temperature prevailing at greater depth the quicksilver minerals would not be so effectively deposited from the solutions that carried them as in the cooler rocks near the surface. Consequently a decrease in the amount of ore from the surface downward is to be expected.

So far as observed, the ores show no considerable downward enrichment through the action of descending surface waters. Small particles of a mineral that may be metacinnabarite, the black sulphide of quicksilver, which is generally believed to be formed as a secondary sulphide, have been seen at the Parks prospect, but their number is not great. As noted by Lindgren,[1] "the sulphide of mercury is practically insoluble in water, and ordinarily the processes

[1] Lindgren, Waldemar, op. cit., p. 801.

of oxidation in the outcrop of the ore deposits are of little importance." Consequently a decided decrease in the tenor of the ore in depth through absence of downward enrichment is probably not to be expected.

POSSIBLE FUTURE AREAS.

The mineralization by which quicksilver was introduced clearly seems to have accompanied the intrusion of the igneous rocks. The neighborhood of these intrusives is therefore the place to prospect for lodes of this metal. All the known intrusions of these rocks have been indicated on Plate X. Much of the region, however, is still unexplored, and consequently other bodies of these rocks probably exist in the places that have not been studied.

The quicksilver minerals near Iditarod were found close to the contact of the large igneous masses, but at the other prospects they occur near the contact of smaller bodies, some of them only a few feet wide. The search for the exposed large igneous masses is relatively simple, for most of the intrusive rocks are more resistant than the surrounding sediments and therefore are somewhat more prominent topographically than the other rocks. The smaller dikes and sills usually do not form noticeable topographic features and are more irregular in their distribution. Most of the small dikes are more or less closely associated with the larger igneous masses and are abundant a short distance from these bodies. In many places, however, the larger masses, from which the dikes are offshoots, are not exposed at the surface, and their presence can be inferred only from the abundance of the small dikes. Search for places of this sort is exceedingly difficult, and they can be found only by close scrutiny of the float and bedrock exposures. When the dikes are found, prospecting to determine whether or not quicksilver mineralization is associated with them will usually be slow, laborious work.

The intrusive rocks by which the quicksilver mineralization was introduced cut the Cretaceous rocks but are believed to be older than the late Tertiary and recent effusive igneous rocks and sediments. Consequently prospecting for deposits of this sort does not seem warranted in areas occupied by rocks of more recent age than the younger part of the Tertiary.

Although the search for quicksilver deposits might disclose others than those now known, the character and occurrence of those that have been found and the difficulties of reduction and marketing seem to indicate that not many productive deposits will be opened in the region. A search for gold placers in the vicinity of the igneous rocks would probably be far more profitable than the same amount of search for quicksilver deposits.

ECONOMIC CONDITIONS AFFECTING THE PRODUCTION OF QUICKSILVER.

Quicksilver ores are relatively rare in nature. Consequently a brief statement as to the general uses of this metal, the amount produced, and the value has been thought desirable. This statement is given because only by considering these different factors can the economic conditions which affect the production of quicksilver be realized and properly evaluated in determining the probable future of any particular deposit.

McCaskey [1] describes the uses of quicksilver as follows:

> Quicksilver is used mainly in the manufacture of fulminate for explosive caps, of drugs, of electric appliances and scientific apparatus, and in the recovery of precious metals, especially gold, by amalgamation. A new use in Scotland is the floating of lights of lighthouses upon a body of quicksilver. A use in England, in the United States, and possibly elsewhere, is the coating of ships' bottoms with a paint containing quicksilver, to prevent organic growth. Mercuric oxide (red oxide of mercury) is the active poison in antifouling paint successfully used on ships' bottoms. The metal appears to be but little employed in silvering mirrors, as nitrate of silver is now chiefly used for the purpose. Increasing use of quicksilver is probably to be expected in the manufacture of electrical appliances and of fulminates, and possibly of paints for protective coatings on metals. The demand for quicksilver for amalgamating gold and silver has greatly decreased, as is well known, with the decreased supply of free milling ores and the increased application of cyanidation to gold and silver ores. Industrial chemistry and inventive genius are to be looked to for increasing the demand.

The production of quicksilver for the world in 1913, according to figures compiled by McCaskey,[2] stated in metric tons of 2,204.6 pounds, was as follows: Spain, 1,490 tons; Italy, 988 tons; Austria-Hungary, 855 tons; United States, 688 tons; Mexico and other countries (estimated), 150 tons; total for the year, 4,171 metric tons. The exports of quicksilver from the United States in 1914, according to records of the Department of Commerce, were 33,900 pounds, or a little more than 15.3 metric tons; the imports of quicksilver in 1914, according to the same authority, were 685,604 pounds, or a little less than 311 metric tons. Imports are subject to a duty of 10 per cent ad valorem. In the United States 33 mines and prospects produced quicksilver in 1914. Of these, 23 were in California and the other 10 in Arizona, Nevada, and Texas. Formerly a small amount of quicksilver was produced also in Oregon, Utah, and Washington, but in recent years none of the quicksilver mines in these States have been in operation.

---

[1] McCaskey, H. D., Quicksilver in 1913: U. S. Geol. Survey Mineral Resources, 1913, pt. 1, pp. 198–199, 1914.

[2] Idem, p. 210.

According to statistics furnished by the Department of Commerce the imports of quicksilver into Alaska during 1914, all from the States, were as follows:

Imports of quicksilver into Alaska in 1914.

Place of shipment.	Amount (pounds).	Value.
Seattle	13,176	$8,477
San Francisco	1,275	607
	14,451	9,084

The following table gives the amount of ore treated and the recovery, by States, for 1913:[1]

Quicksilver ore treated and average recoveries by States, in 1913.

State.	Ore treated (short tons).	Metal recovered per ton (pounds).	Percentage of ore recovered as metal.
California	119,159	9.8	0.49
Nevada	8,755	14.1	.71
Arizona and Texas	8,464	26.7	1.34
Total and average for United States	136,278	11.1	.555

McCaskey,[2] in a preliminary statement, gives the following notes on the market and prices of quicksilver in 1914:

The domestic quicksilver market was unfavorable and the prices very low during the first seven months of 1914, but upon the outbreak of the European war the prices jumped and producers in a position to profit were encouraged to make their maximum output. The average San Francisco domestic price was $40.23 a flask of 75 pounds for the year 1913, against $42.05 in 1912 and $46.01 in 1911. * * * It is estimated that * * * the average price for the year [1914] will therefore be about $49—the highest since 1890. The total productive capacity of the quicksilver mines of this country as at present known is by no means unlimited, and although high prices may bring spurts of activity and new ore bodies may at any time be discovered, the present outlook is not for excessive production. These facts and the present improbability of excessive importation indicate high prices throughout the war, at least.

[1] McCaskey, H. D., Quicksilver in 1913: U. S. Geol. Survey Mineral Resources, 1913, pt. 1, p. 201, 1914.

[2] McCaskey, H. D., Quicksilver production in 1914: U. S. Geol. Survey Press Bull. 201, January, 1915.

GOLD PLACERS OF THE LOWER KUSKOKWIM, WITH A NOTE ON COPPER IN THE RUSSIAN MOUNTAINS.

By A. G. MADDREN.

SCOPE OF REPORT.

During the summer of 1914 the writer investigated the mineral resources and general geology of that portion of the Kuskokwim region which extends southwestward from the well-known Iditarod gold placer district to the basins of Aniak and Tuluksak rivers, large tributaries of Kuskokwim River from the south. Placer gold has been known to occur in these basins since 1908 and has been mined in a small way from that year to the present.

This report treats primarily of placer-gold deposits on upper branches of Tuluksak and Aniak rivers, which flow from opposite slopes of a mountain ridge that separates these two drainage basins. Together these basins may be conveniently designated the Tuluksak-Aniak gold placer district. The combined drainage areas lie chiefly between latitude 60° 30′ and 61° 30′ N. and longitude 159° and 161° W. The direct distance between the Tuluksak-Aniak and Iditarod districts is about 150 miles. (See Pl. X, p. 270.) Within the intervening area several minor localities of mineral deposits are known. Those in which active interest was being shown during 1914 were visited. Other reported prospects at widely separated places throughout this general field could not be visited because of lack of time, facilities, and definite information as to their exact position. However, such notes as were gathered about them are here presented.

Information was also gathered from available sources concerning mining developments and prospects southwest of the field personally examined, including the section of the Kuskokwim Mountains that extends from the Tuluksak-Aniak district to Bering Sea, a direct distance of about 180 miles. (See Pl. X.) It was intended at the beginning of the season to visit all the active mining localities of the lower Kuskokwim region, but on entering the field it was found necessary to curtail this plan because of the isolation of the several camps, the lack of summer trails and overland transportation facilities, and the general scarcity of supplies both at the trading posts along Kuskokwim River and at the mining camps. No pack animals

were available for carrying a camp and supplies over the mountains south of Kuskokwim River. It was not possible to cover the whole region in the time available by boating up the swift tributaries of the Kuskokwim to the mountains and then man-packing with light equipment to the several mining camps. Very rainy weather during most of the season was also a great hindrance to field observations. As a result personal field examinations were, by force of circumstances, limited to the upstream half of the lower Kuskokwim region as a whole and were confined chiefly to the neighborhood of the main river except in the Tuluksak-Aniak district. This district was covered by back-packing a few necessities overland a distance of 75 miles on the outgoing trip and the same distance on the return and by depending almost entirely on the generous hospitality of the miners and prospectors on the several creeks for shelter and food from their scanty stores.

ACKNOWLEDGMENTS.

The writer wishes to record grateful appreciation to Messrs. Huber, Schmidt, and Heckman, on Ophir Creek; Mr. R. S. Eskridge, on Bear Creek; Mr. W. Y. Fisher, on Marvel Creek; Mr. and Mrs. Johnstone, on Cripple Creek; and Mr. Parks, on Loco Creek. Mr. Gordon Bettles, of Kolmakof, not only gave his personal guidance during a three days' trip to the Russian Mountains to examine lode prospects but entertained the party at one of his cabins during that time.

For information regarding mining and prospecting in that part of the region which was not visited the writer is under obligations to Messrs. Johnson, Lindstrom, Fowler, Joaquin, Felder, Moran, King, Heron, Hitzner, and others. Mr. Charles Estmere has kindly furnished a drainage map of Kiselalik and Kuethluk rivers based on traverses made by him through those valleys during the spring of 1914.

The writer was accompanied throughout the trip by Burt Kennedy as geologic field assistant, and from the middle of July to the later part of September by Robert Plummer as field utility man.

ITINERARY.

The field here discussed was reached by the Seattle-Skagway coastal steamship route, the railroad across White Pass to Whitehorse, and the Yukon River steamboats to Iditarod.

Field work began in the middle of July with an overland journey from the Iditarod district, in which the party followed a pack trail 65 miles long that crosses the Kuskokwim Mountains and has its southern terminus at Georgetown, a settlement on Kuskokwim River

about 400 miles above its mouth, or 250 miles above Bethel, the supply port for Kuskokwim Valley. On the way to Georgetown the placer gold locality on the middle course of Crooked Creek, a few miles west of the trail, was visited. From Georgetown Kuskokwim River was descended by a poling boat for about 90 miles to the native village of Ohagamut (Oknagamute). The gold placer locality on New York Creek, a few miles above Hoffmans (Napaimut), was visited; the prospect of cinnabar about 5 miles below Kolmakof was examined; and a side trip was made to a copper lode locality in the Russian Mountains about 12 miles northwest from Kolmakof.

From Ohagamut the outlying northern foothills of the mountains that lie between Tuluksak and Aniak rivers, about 15 miles distant. were reached by ascending a tortuous chain of creeks and ponds to Whitefish Lake, a considerable body of water, 6 miles wide and about 10 miles long, that lies along the southern border of the expansive lowlands which characterize the lower part of the Kuskokwim Valley.

From Whitefish Lake an overland back-packing trip was made southward about 75 miles through the mountains of the Tuluksak-Aniak district. Ophir Creek, a stream about 15 miles long, that discharges into Whitefish Lake, and along which prospects of placer gold occur, was ascended to its source in Rockpile Pass, at the base of Mount Hamilton; and Bear Creek, which heads against Ophir Creek and forms one of the chief headwaters of Tuluksak River, was descended for about 15 miles to the scene of placer gold mining along its middle course. Thence the divide which separates the drainage basins of Tuluksak and Aniak rivers was crossed by way of East Fork of Bear Creek, and the valley of Dominion Creek was descended to its junction with Robin Creek, along which prospects of placer gold are reported to have been discovered. Robin Creek was ascended to its source on the north flanks of Marvel Dome, which was skirted on the west by crossing the headwaters of Eagle Creek as far as Marvel Creek, a stream about 6 miles long that drains the southern slopes of Marvel Dome and empties into Eagle Creek about 2 miles above its mouth. Marvel Creek is about 30 miles south of the diggings on Bear Creek and is the most productive gold-bearing stream that has been discovered in the Aniak basin up to the present time. Field observations were continued southward about 15 miles from Marvel Creek to Cripple Creek and two of its headwater branches, Dome and Loco creeks, the gravels of which contain some placer gold.

The return was made overland to Whitefish Lake by the same general route followed on the southward trip, and thence to the main river by the boat route. Kuskokwim River was descended to

the settlement of Bethel, where the party arrived late in September. Seattle was reached early in November by an ocean voyage through Bering Sea and across the Pacific on a small trading schooner, which makes the trip between that port and Kuskokwim River about twice each summer.

GENERAL GEOGRAPHY.

The major topographic features of this region are a broad belt of mountainous highlands, named the Kuskokwim Mountains, which extend inland northeastward from Cape Newenham, on Bering Sea, for fully 500 miles, and a trunk valley system, drained by Kuskokwim River, that extends into the interior approximately the same distance as the mountain belt.

KUSKOKWIM VALLEY.

The Kuskokwim Valley may be divided into three natural geographic provinces—a lowland province, which lies along the northwestern flanks of the Kuskokwim Mountains and extends about 200 miles inland from the mouth of the river on Bering Sea; a central province, along the middle length of the river, which is deeply entrenched for a distance of about 150 miles from east to west across the entire width of the Kuskokwim Mountain belt, diagonally transverse to the trend of the mountains; and an extensive interior basin province, which lies along the southeastern flanks of the inland section of the Kuskokwim Mountains and is occupied by the large headwater branches and upper course of the main river.

Inasmuch as the headwater or interior basin province of the Kuskokwim Valley, together with the eastern portion of the central province downstream as far as Georgetown, are described by P. S. Smith in another part of this bulletin (p. 249), further mention of these areas will not be made here. The same statement applies to that part of the Kuskokwim Mountains which extends northeastward from the section across them between Georgetown and the Iditarod mining district. A reference to the Kuskokwim-Iditarod section is contained in Smith's report (p. 252), and a large part of this range northeastward from this section has been described in previous Survey publications by Eakin[1] and the writer.[2] Therefore the descriptions of the Kuskokwim Valley here presented will be confined to the western section of the central province from Georgetown downstream and to the lowland province.

An extensive tract of lowlands borders the lower course of Kuskokwim River for a distance of about 300 miles above its mouth. About

[1] Eakin, H. M., The Iditarod-Ruby region, Alaska: U. S. Geol. Survey Bull. 578, 1914.

[2] Maddren, A. G., The Innoko gold-placer district, Alaska: U. S. Geol. Survey Bull. 410, 1910; Gold-placer mining developments in the Innoko-Iditarod region: U. S. Geol. Survey Bull. 480, pp. 236–270, 1911.

100 miles of these lowlands farthest from the sea are of the true valley type in that they occupy a broad area within the Kuskokwim Mountain belt that is bounded by sloping highlands on each side. The remaining 200 miles of lowlands, through which the river flows to the sea, may be more properly considered as being of the coastal-plain type in that they are bounded by highlands only along their southeastern borders within the limits of the Kuskokwim drainage basin, and in that the main river in this stretch is more or less affected by the tides of Bering Sea. On the north the Kuskokwim lowlands merge imperceptibly into similar lowlands that extend along the lower course of Yukon River. These two coalescent lowland tracts expand westward between the lower courses of Kuskokwim and Yukon rivers, a great triangular coastal plain whose area is fully 30,000 square miles. Kuskokwim River flows southwestward through the southern portion of this great lowland in general parallelism with the trend of the Kuskokwim Mountains, on the southeast, at distances of 15 to 30 miles from their foothills. All the large tributaries to the main river throughout this section flow from these mountains.

The tides of Bering Sea extend up Kuskokwim River for fully 100 miles above its mouth, through which distance extensive mud flats and bars obstruct its channel. For another 100 miles upstream from this estuarine portion the current of the river is alternately slackened and accelerated by tidal flow and ebb.

Among the rivers of Alaska the Kuskokwim ranks second to the Yukon in length, volume, and navigability. Light-draft ocean vessels may ascend its tidal portion for a distance of about 150 miles above Goodnews Bay, on Bering Sea, or to the settlement of Bethel, and river steamboats may follow its channel for fully 500 miles above Bethel.

KUSKOKWIM MOUNTAINS.

SUBDIVISIONS.

Geographically the Kuskokwim Mountains may be divided into two principal tracts, northeastern and southwestern, of about equal length and breadth, separated by the middle course of Kuskokwim River. The northeastern or inland tract lies north and northwest of the middle and upper parts of Kuskokwim River, between that stream and tributaries to the Yukon which drain the northwestern flanks of the mountains. The southwestern mountain tract lies south and southeast of the middle and lower parts of Kuskokwim River, between the Kuskokwim and the headwaters of Nushagak and Togiak rivers, which flow southward into Bristol Bay. (See Pl. X, p. 270.)

RELIEF.

In general the Kuskokwim Mountains may be described as a belt of strongly rolling ridges and spurs, 80 to 100 miles in width, in which the summits range from 1,000 to 3,000 feet above sea level, and the most persistent trend is northeast. There are, however, considerable variations from this general trend in parts of the belt.

The most pronounced features of relief in this mountain belt are isolated groups of rugged peaks and higher domelike mountain masses scattered here and there throughout the belt and rising to altitudes of 4,000 to 7,000 feet, so that they stand prominently above the highland elevations that occupy the greater part of the belt. The highest peaks in the belt are situated along the middle of its southwestern division between the sources of Kuethluk and Kanektok rivers. One of the most prominent of these peaks stands at an altitude of about 7,300 feet, and several others in this vicinity, including one named Mount Oratia, are about 6,000 feet in altitude. Throughout the remainder of the Kuskokwim Mountains, however, there are few summits more than 5,000 feet in altitude, and in the inland tract, north of the main river, there are no peaks over that height.

The relief immediately along Kuskokwim River, produced by its direct erosion, is most pronounced in the upper half of the central valley province. In this part a well-developed gorge is entrenched to a depth of more than 1,000 feet across the highland belt for about 50 miles, extending 20 miles above and 30 miles below Georgetown. The river is here confined on both sides by steep mountain slopes, spurs from which are truncated to form rocky bluffs along the banks at frequent intervals. This is the only part of the trunk valley that is so restricted as to present marked relief immediately along both banks. Downstream from this section, throughout the remainder of the mountain belt, broad valley lowlands border the south bank of the river. In sharp contrast to these lowlands, however, the north bank of this part of the river is formed mostly of more or less continuous stretches of rocky bluffs which are truncated from the highland ridges and stand from 200 to 600 feet above the river.

The valleys of the larger tributaries to the Kuskokwim within its gorge section, such as George River and Crooked Creek, have entrenched forms which correspond to that of the trunk valley; but in the lower half of the mountain province the large tributaries occupy rather broad basins which conform with the wider trunk valley in this part. The basins of Aniak River, on the south, and of Kolmakof and Owhat rivers, on the north, are some of the largest of these wider valleys.

DRAINAGE.

Kuskokwim River and its tributaries drain by far the largest part of the Kuskokwim Mountains. In general the main drainage lines show strongest development along the structural trends of this mountain belt—that is, the largest and longest tributaries, as well as the greater part of the trunk river, occupy valleys which extend mainly in a southwest direction, with the trend of the mountains. The most marked exception to this trend of the drainage is shown by the course of the main river in its middle section, which cuts somewhat diagonally across the mountain belt from east to west. Above and below this transverse section the river follows the southeastern and northwestern flanks of the mountain belt, respectively.

GLACIATION.

There is evidence that many of the higher groups of peaks of the Kuskokwim Mountains which stand from 2,000 to 3,000 feet above the main part of the highland belt were the centers of well-developed mountain glaciation during a former period when the drainage conditions of this region were somewhat different from those of the present, or at least that the glaciation considerably modified the character of the former drainage system, from which the present drainage system is inherited.

On the slopes of the high peaks between the headwaters of Kuethluk and Kanektok rivers there are mountain glaciers of considerable size, which appear to be the remnants of much larger and longer mountain valley glaciers. There is ample evidence that formerly such glaciers were numerous and extensive along the central part of the southwestern division of the Kuskokwim Mountains, where they appear to have been developed on almost all the mountain masses above 4,500 feet in altitude. This evidence consists of steep cirque basins at the heads of some of the mountain valleys and bowlder moraines heaped along the valley floors below the cirques, in some places for only a mile or so and in others for many miles. There are also widespread deposits of glacial outwash gravels along these valleys, beyond the moraines, some of which extend for many miles. Some of the details of these glacial features and their economic significance will be discussed in connection with the placer gold deposits which they have affected.

MINERAL RESOURCES.

HISTORICAL OUTLINE.

Cinnabar appears to have been the first mineral authentically reported to occur in the Kuskokwim Valley. For a number of years it was the only mineral definitely mentioned in the few reports pub-

lished on this region. An account of the discovery and development of these deposits is presented as a separate paper in this bulletin (pp. 272–291).

During the pioneer period of placer mining in the interior of Alaska, before the rush of gold seekers to the Yukon Valley in 1897, apparently only a few transitory attempts were made to prospect in the Kuskokwim Valley. Prospectors are known to have passed through this valley as early as 1889, when Frank Densmore led a party from the Tanana Valley to the Kuskokwim and descended that river to the Yukon portage. About the same time another pioneer prospector, Al King, made the same trip. Afterward Joe Goldsmith crossed from the Yukon by way of the Russian mission portage and ascended the Kuskokwim for several hundred miles. James Cleghorn and Harry Mellish also crossed this portage and wintered at Kolmakof. None of these men, however, appear to have made discoveries of mineral deposits of sufficient value to induce them to remain in or return to the Kuskokwim Valley.

This region appears to have been neglected as a field for prospecting during the early years of the gold excitement that centered in the Klondike and spread along various tributaries of the Yukon. It was not until the Nome boom, in Seward Peninsula, reached its height during 1900 that further attention was directed toward the Kuskokwim region. One of the results of the rush of people to that district was the movement of a small number of men from Nome to the region about the mouth of the Kuskokwim during the summer of 1900, and they prospected in that vicinity for several years. Placer gold was discovered at several localities in the vicinity of Goodnews Bay, and productive mining, on a small scale, was undertaken on Butte Creek, in the basin of Aalalik River near the settlement of Quinhagat, and has been carried on for the last ten years or more.

During the winter of 1900–1901 a typical dog-sled stampede to the Kuskokwim Valley was made by a considerable number of men from Nome. The movement was based on vague rumors of the discovery of placer gold on a stream designated "Yellow River," but the location of this stream in the Kuskokwim Valley does not appear to have been even approximately fixed. Some parties searched for it as far up the Kuskokwim as its headwater branches in the Alaska Range, near Mount McKinley. Ultimately a number of the stampeders arrived on the stream now named Ophir Creek, in the Tuluksak-Aniak district, and decided it to be their goal. Prospects of placer gold are reported to have been found on this stream by these men, and old hewn stakes are now standing in this valley to testify that claims were located there some years ago. Old-timers who participated in this excitement, which is known as the "Yellow River" or "Pete McDonald" stampede, state that the name "Yellow River" was

applied to the sluggish outlet of Whitefish Lake, into which Ophir Creek discharges; and that it was so named because the water of the outlet stream is discolored by the combination of iron oxide and decayed vegetable matter so characteristic of swamp water. Others claim that "Yellow River" should be identified with Aniak River because of the silt which is stated to discolor one or more of its headwater branches.

About the time of the "Yellow River" stampede copper-bearing lode prospects were located in the Russian Mountains northwest of the trading post of Kolmakof, but these lode claims and the placer claims on Ophir Creek also were soon relinquished by failure to perform assessment work upon them, and no further interest was shown in them until 1913–14, when they were relocated.

The basin of Holitna River, a large south-side tributary of the Kuskokwim, received considerable attention from prospectors during 1902–3. W. R. Buckman, one of these men, made the first comprehensive sketch map of this extensive drainage area. Outcrops of coal-bearing rocks were noted at several localities. Although colors of gold are reported to occur in many of the gravel bars of this basin, productive deposits have not been found up to the present time.

The discovery of placer gold on the headwaters of Innoko River in 1906 caused a considerable movement of prospectors from Nome up Kuskokwim River the following year. It is estimated that several hundred persons left Nome for the Innoko diggings by way of the Kuskokwim River during 1907. Most of them arrived at their destination after various delays and risks due to unsatisfactory transportation, especially across Bering Sea and into the mouth of the river. A few of these persons, however, did not go all the way to Innoko district but stopped at various points along Kuskokwim River and turned their attention to prospecting some of its tributaries.

One of these parties, of whom William Fisher was a member, ascended Tuluksak River. After finding colors of gold in the gravel bars at several points along that part of the main stream that flows from the mountains, the Fisher party finally discovered gold in commercial quantities on Bear Creek, either in 1907 or 1908. Besides staking two discovery claims on the main creek, the party also located discovery claims at the mouths of two of its tributaries, Bonanza and Spruce creeks. Open-cut mining has been conducted along this stream since that time.

The discovery of the rich Iditarod placer gold deposits during the winter of 1908–9 led to the finding of gold prospects during the summer of 1909 in the basins of George River and Crooked Creek, tributaries to the Kuskokwim running southward from the Iditarod

district. The rush of people to the Iditarod in 1910 led to an overflow into the central part of the Kuskokwim Valley during that year and the widespread location of placer claims throughout the basins of George River and Crooked Creek and along the upper valley of Iditarod River. One of the results of this excitement was the establishment of a considerable settlement, named Georgetown, on Kuskokwim River at the mouth of George River in the autumn of 1910. The failure of the prospects on George River and Crooked Creek to develop into large producers of gold caused the practical abandonment of this settlement by the spring of 1911.

At this time the revival of rumors as to the richness of the gold prospects in the Goodnews Bay district and reports of more recent discoveries there caused many of the disappointed men congregated at Georgetown to go to the mouth of the Kuskokwim as soon as the river was free of ice. On finding these reports greatly exaggerated most of the men who took part in the movement returned up Kuskokwim River during the spring and summer. Some of them, however, undertook to prospect several tributaries to the lower Kuskokwim before returning. One of these parties, consisting of Harry Buhro, Kid Fisher, and Fred Labelle, concluded to examine the basin of Aniak River. They appear to have based their decision on the report that a lone and somewhat mysterious prospector, named "Old man" Keeler, had made discoveries of gold in the gravel bars of this river during the summer of 1910, and that a small party of prospectors, who were trailing Keeler, had built a cabin at the mouth of a stream, now named Dominion Creek, in the autumn of 1910 and had spent part of the previous winter there. Buhro, Fisher, and Labelle verified the occurrence of bar prospects and then undertook a somewhat systematic search for the streams from which the gold in the bars might be derived. In August, 1911, Buhro discovered coarse gold on a stream, now named Marvel Creek, in the basin of Salmon River, the westernmost headwater branch of Aniak River. More or less unsuccessful mining has been done on Marvel Creek since 1912.

Other parties who descended the Kuskokwim from Georgetown in 1911 ascended Eek, Kuethluk, and Kiselalik rivers, large streams emptying into the lower Kuskokwim and draining the northwestern flanks of the Kuskokwim Mountains southwest of Aniak and Tuluksak rivers. Prospects of placer gold were discovered on the upper course of Eek River in two creeks, one named Rainy and the other Kopon or Gobown. Although prospecting has been continued on these creeks and others in their vicinity for the last three years, no productive mining has been done up to the present time. In 1913, however, shallow placer deposits were discovered in a short

gulch stream on upper Kuethluk River, named Canyon Creek, from which about $14,000 worth of gold was produced during the summer of 1914.

ECONOMIC CONDITIONS.

The foregoing chronologic account of prospecting in the Kuskokwim Valley, while by no means complete as to details, shows that there has been a more or less constant though shifting movement of prospectors throughout this region during the last 15 years. Although the whole valley may be considered to have been covered in a general way, much of the prospecting has been only of a preliminary character.

Such productive localities as have been found point to the conclusion that other deposits of commercial importance may be expected to occur wherever intrusive bodies of granitic rocks cut the country rocks, and that there is still a large field for prospecting in this region, especially for the systematic prospecting that will search out the areas of granitic intrusive rocks and examine them thoroughly in the manner that is suggested on page 306.

Systematic prospecting has been greatly handicapped by the scarcity of permanent supply posts at convenient points along the main river. Most of the prospectors have been obliged to consume much of their time each year in transporting their outfits long distances in order to reach the parts of the region they desired to examine. None of the small productive camps have resulted in the establishment of settlements at the scenes of mining that would furnish facilities of supply near at hand and enable prospectors to devote the greater part of their time to the thorough examination of surrounding areas. From time to time the promise of discoveries in one locality or another has stimulated the establishment of supply posts at a number of points along Kuskokwim River, but the unsettled condition of population and mining development has prevented these posts from becoming fixed with a degree that could be depended upon from year to year.

SETTLEMENTS AND TRANSPORTATION.

The native settlement of Bethel, on the tidal portion of Kuskokwim River, about 100 miles above its entrance into Bering Sea, is the most important supply station for this region, and probably it will always be of commercial importance because of its natural location as a port of entry for ocean-borne traffic to the extensive region drained by Kuskokwim River. Bethel was established in 1886 as the local headquarters of a Moravian missionary society, and since that time has served more or less as a trading center for the native

population and a place of supply for prospectors within reach of it. Shallow-draft seagoing power vessels can reach Bethel during the season of open navigation, from June to October, and for the last five or six years a somewhat irregular trade has been carried on between Bethel and Seattle, Wash. Kuskokwim River is navigable for stern-wheel steamboats for fully 500 miles above Bethel. Consequently this place is a logical point for the discharge of ocean traffic and its transshipment up the river. Without doubt the greater part of all supplies for the Kuskokwim region will be brought to it by this water route, no matter where future developments in the valley may take place.

Several river steamboats have been operated on Kuskokwim River each summer since about 1907, when the miners came from Nome to the Innoko district by way of this river. The trade of these boats increased until 1911, when several additional boats were placed upon the river, but since then it has fallen off and in 1914 only one large river boat was required to carry all the freight offered. At its maximum the freight carried on the river each summer amounted to about 2,500 tons, but in 1914 it had dwindled to about 500 tons.

The excitement that resulted in the building of the mushroom settlement of Georgetown in 1910–11 greatly stimulated commercial activity along Kuskokwim River for a year or so. Besides the establishment of several stores at Georgetown, a well-stocked station was placed at the site of the old Russian trading post of Kolmakof, about 65 miles below Georgetown or 150 miles above Bethel. The Kolmakof station was established with the primary object of serving the prospective diggings in the Aniak and Tuluksak basins, to which supplies could be hauled across the Kuskokwim Valley lowlands by way of a winter sled trail. However, both the Kolmakof and Georgetown stations were discontinued in the spring of 1914, and the goods they contained were transferred up the river to a station on Tacotna River, which is still maintained. These changes were due to a marked falling off in business activity because of the fact that mining developments in the Tuluksak-Aniak district have not progressed as rapidly as was expected.

GENERAL DISTRIBUTION.

PLACER GOLD.

Gold is the chief mineral resource now known within the lower Kuskokwim region. Prospects of placer gold are widely distributed in the gravels of a number of streams throughout the mountain belt, but gold has been mined in commercial quantities at only a few localities. The most productive of these are on Bear Creek, in the Tuluksak basin; Marvel Creek, in the Aniak basin; Canyon Creek, on

upper Kuethluk River; and Butte Creek, in the basin of Aalalik River. All these localities are in the southwestern division of the Kuskokwim Mountains, and at all of them mining is now being carried on. There are also a number of other creeks within and between the basins of these streams on which prospects of gold have been found. These will be noted in the descriptions of the productive areas.

In that part of the mountain belt that lies north of the middle Kuskokwim, between this river and the Iditarod district, placer gold is being mined in small amount on Crooked Creek, a tributary that empties into the Kuskokwim about 18 miles below Georgetown. Good prospects are being developed also in a small basin, drained by New York Creek, near the bank of the Kuskokwim a few miles above Hoffmans (Napaimut). Prospects of gold are reported to occur on Mission Creek, which flows into the Kuskokwim about 20 miles below Kolmakof from the southwestern part of the Russian Mountains, but no active interest was being shown in this creek during 1914.

During the winter of 1910–11 about 100 men were engaged in prospecting along the upper Iditarod Valley, and since then a few persons have visited this area from time to time. It is reported that prospects of fine gold may be obtained from the bars along the upper course of this river 30 to 70 miles southwest of the Iditarod mining district. The gold in the river bars appears to be traceable to creeks tributary to the river on the right side. These creeks, named in ascending order, are Dome, Moose, Little, Tiny, Slate, Rainy, and Williams. Little Creek is the only one on which valuable prospects were found and is reported to have yielded pans showing 1 to 2 cents worth of fine gold from some of the gravels. The tributaries on the left side of this part of Iditarod Valley appear to be barren of gold. No productive mining has been done within this area up to the present time.

LODE PROSPECTS.

An ore deposit, of the fissure-vein type, composed chiefly of chalcopyrite and arsenopyrite and containing copper, gold, and silver, occurs in the Russian Mountains about 12 miles northwest of Kolmakof. This is the only lode prospect in the lower Kuskokwim region on which serious development work is known to have been done. In 1914 it was prospected by means of a shaft to the depth of about 40 feet.

Float specimens of the copper minerals malachite and azurite are reported from the valley of Kuethluk River, and the presence of galena (sulphide of lead) in the same valley is indicated by a few pebbles of this mineral in the bar gravels of this river.

The occurrence of realgar (sulphide of arsenic) has been noted by prospectors in the headwater area of Eek River.

A prospect of cinnabar occurs on the right bank of Kuskokwim River about 5 miles below the trading post of Kolmakof. It is described elsewhere in this bulletin (pp. 280–286).

COAL PROSPECTS.

Coal crops out in the foothills along the northwest flanks of the Kuskokwim Mountains on Eek and Kuethluk rivers, but little is known either of the areal extent of the coal-bearing formation or of the number and thickness of the beds, for no development work has been done on them.

GENERAL CHARACTER OF MINERALIZATION.

In a broad geologic sense, the widely scattered occurrences of gold and other metals mentioned above appear to be connecting links in a chain of mineral deposits of closely related origin, which seem to have a general though somewhat sporadic development throughout the Kuskokwim Mountain belt. However, they do not warrant the statement that the Kuskokwim Mountains, throughout their extent, are characterized by a mineral belt, in the usual sense of that term.

The agent that introduced or governed the metallic mineralization, especially of gold, appears to be the igneous rocks, chiefly of siliceous granitic types, which are intruded into the country rocks in the form of large and small dikes and extensive massive bodies. Both forms of intrusion are known to occur at intervals from the Tuluksak-Aniak district to the Iditarod district and thence northeastward to the Innoko district. The gold of the productive placer deposits in these districts is, without exception, found in close association with the intrusive rocks and the altered contact zones about their borders. It is reported that the same association with granitic intrusions is characteristic of the placer gold deposits of the Kuethluk, Eek, and Aalalik basins, southwest of the Tuluksak-Aniak district, and the Candle Creek area, south of the Innoko district. Thus an intimate relation appears to be established between the placer gold deposits of the Kuskokwim Mountain belt and the intrusive siliceous granitic rocks that are irregularly but persistently distributed at intervals throughout these mountains. So far as now known there is no exception to the broad application of the above statement, although there appear to be local variations in the mode of original occurrence of the gold, both within the masses of the intrusive rocks and in the contact zones of mineralization about them. For example, in the Iditarod district the gold appears to be deposited chiefly within the body of

a massive intrusive granitic rock, but in the Innoko district no massive intrusive rocks occur in the immediate area of gold mineralization and the gold appears to have been introduced by mineralized siliceous dikes that cut the sedimentary country rocks. In the Tuluksak-Aniak district large bodies of the granitic intrusive rocks occur, and the gold of the productive placers on Bear Creek appears to be traceable to these rocks. The alluvial history of the gold-bearing gravels in Bear Creek is so obscured by the presence of glacial outwash gravel deposits of great thickness and extent that it is difficult to trace the placer gold to its primary bedrock source, but there appears to be no doubt that the intrusive rocks of this district have effected the gold mineralization, as in the other districts cited.

SUGGESTIONS TO PROSPECTORS.

The best procedure for prospecting in the Kuskokwim Mountain belt is to search out the areas that contain granitic intrusive rocks, either in the form of large bodies or of dikes, and to confine operations to them or to their vicinity. Special attention should be given to the granitic rocks themselves where they show evidences of veinlets and where they are deeply decayed, as in the Iditarod district. Where the intrusive bodies have been eroded or are in the form of dikes cutting the country rocks, particular attention should be given to the stream deposits that are derived directly from such areas and the zones of contact alteration that generally occur in the country rocks about the borders of the granitic intrusions.

An attempt should be made to recognize the differences between the areas of granitic rocks which have been subjected to mountain glaciation and those which have not, for the unglaciated areas are more favorable for rich placer concentrations. Erosion by glacial ice has been severe enough in some of the higher mountains of the Tuluksak-Aniak district to scatter broadcast any placer gold which may have been accumulated from mineralized intrusive rocks before glaciation occurred. The placer gold deposits of the Iditarod district, on the other hand, illustrate the conditions that may be expected in an area which has not been subjected to glacial erosion, but in which all the evidence points toward slow residual decay of the mineralized granitic rocks and moderate stream concentration throughout a long period of time undisturbed by glacial activity.

TULUKSAK-ANIAK DISTRICT.

LOCATION AND EXTENT.

The Tuluksak-Aniak district comprises the drainage basins of Tuluksak and Aniak rivers, two large tributaries of the Kuskokwim that empty into it from the south at points about 70 miles apart.

The area of the Tuluksak basin is about 1,500 square miles and that of the Aniak basin about 3,000 square miles. The Tuluksak basin lies on the northwestern flanks of the Kuskokwim Mountains, but its headwater branches do not reach far into the interior of the mountain belt. On the other hand, the Aniak basin, which lies east of the Tuluksak basin, is entirely within the mountain belt. Several large headwater branches of the Aniak rise far in the interior of the mountain highland, opposite those of Nushagak and Togiak rivers, which drain a considerable part of the southeastern flanks of the Kuskokwim Mountains. (See Pl. X, p. 270.) The combined area of these two basins lies chiefly between latitude 60° 30′ and 61° 30′ N. and longitude 159° and 161° W. (See Pl. XI, p. 350.)

TULUKSAK RIVER.

The mouth of Tuluksak River is about 60 miles above Bethel, and it is stated that a slight tidal effect is noticeable in the main river up to this point. The lower half of Tuluksak River meanders across the Kuskokwim lowlands by a course fully 60 miles long, though in this part the lowlands are only about 20 miles wide. Within the mountains the Tuluksak has two principal headwater branches, the southern of which is named Fog River and the northern of which is formed by three large streams, named in upstream order Granite, California, and Bear creeks. Each of these creeks occupies a valley of considerable area and is fed by many large tributaries. Bear Creek will be further described under the discussion of its gold placers, the only deposits of economic importance so far developed within the Tuluksak basin.

LOWLANDS BETWEEN TULUKSAK AND ANIAK RIVERS.

The lowlands crossed by the lower course of Tuluksak River extend northeastward up the Kuskokwim to Aniak River, a distance of about 50 miles. Throughout this distance they present the same general aspect, but in their up-river half they are a few miles narrower and occupy a more or less well-defined valley, bounded by rolling highlands on each side. This somewhat confined tract of lowlands within the mountain belt is more clearly a valley than the expansive delta-shaped coastal plain that extends westward from the vicinity of Tuluksak River to Bering Sea along that part of Kuskokwim River which is affected by the tides. The change from the coastal-plain type to the valley type of lowlands is imperceptible, but may be considered to occur between Tuluksak and Aniak rivers, approximately where the Kuskokwim emerges from the mountain belt.

Within the limits of the mountains almost the whole lowland area lies south of the main river. In other words, the Kuskokwim flows along the northern margin of the lowlands, against the flanks of the highlands that form the north slope of the broad lowland valley. The lowland tract contains a practically continuous chain of shallow flood-plain lakes and ponds, with intervening swamps, extending along its southern border against the foothills of the mountains between Tuluksak and Aniak rivers. Nearly all the drainage from the mountains between these two rivers empties into this chain of lakes and ponds, from which it flows indirectly into the Kuskokwim across the wide tract of lowlands by way of a number of very tortuous and for the most part sluggish creeks and sloughs. Thus this lowland tract is poorly drained and is subject to widespread inundations at times of flood. The only streams that maintain well-established courses from the mountains on the south across the full width of the lowlands to the Kuskokwim are Tuluksak and Aniak rivers. Even these large streams maintain their channels with difficulty, as is shown by their wide meandering.

The largest of the shallow bodies of water on this lowland tract is Whitefish Lake. Although 6 miles wide and about 10 miles long this lake has a maximum depth of only about 30 feet and in the greater part of its area is less than 10 feet deep. Whitefish Lake receives a stream about 15 miles long, named Ophir Creek, on which occur prospects of gold that will be described in the discussion of placer deposits.

ANIAK RIVER.

Lower Aniak River flows across the Kuskokwim lowlands in a meandering channel approximately 45 miles long, at a place where the lowlands are about 15 miles broad. South of the lowland tract, within the mountain highland belt, the broad basin of the Aniak is drained by three principal branches, the westernmost of which is named Salmon River and the others Middle Fork and East Fork, respectively. Little is known about the two latter branches beyond the fact that their sources lie well within the mountains, opposite the headwaters of Nushagak River, to the south. Although prospects of gold are reported to occur within the areas drained by the Middle and East forks of the Aniak, so far the only productive deposits of placer gold that have been developed within this basin occur in the valley of Salmon River.

MOUNTAINS BETWEEN TULUKSAK AND ANIAK BASINS.

The wide basin of Aniak River separates a portion of the Kuskokwim highland on the west from the main part of the mountain belt, so that a considerable mountain area occupies a somewhat

isolated position between the upper courses of Tuluksak and Aniak rivers. The extent of this mountainous area is about 30 miles from east to west and 60 miles from north to south. It is surrounded by broad lowlands on all sides except the south, where it merges with the main mountain belt that extends southwestward.

The higher ridges of this area, which form the divide between the Tuluksak and Aniak drainage basins, have average altitudes of about 3,000 feet above sea level. The spurs that descend from these ridges to the lowlands form a wide belt of rolling foothills on the west, north, and east flanks of the mountains. About the center of the area several summits stand prominently above the general elevation of the main ridges. The highest of these summits, Marvel Dome, has an altitude of about 4,800 feet. Mount Plummer, whose altitude is about 4,600 feet, stands about 4 miles northwest of Marvel Dome, between the sources of East Fork of Bear Creek on the north and Eagle Creek on the south. A third summit, Mount Hamilton, about 4,300 feet in altitude, stands in the northern part of the area at the sources of Bear and Ophir creeks. Because of its somewhat outlying position, Mount Hamilton overlooks a broad expanse of the Kuskokwim Valley lowlands and may be seen for many miles from points both up and down the main river, so that, although not the highest, it is one of the most prominent summits in the district and serves as a general landmark. Locally Mount Hamilton is known as Bear Creek Dome.

BEAR CREEK AND ITS GOLD PLACERS.

TOPOGRAPHIC FEATURES.

Bear Creek is one of the largest headwater tributaries of the northern branch of Tuluksak River. (See Pl. XI, p. 350.) Its sources occupy a large semicircular basin which lies immediately south of Mount Hamilton and opens toward the east. From this basin the creek flows southeastward for about 5 miles and thence southwestward for about 10 miles through two high mountain ridges, which form the dominant topographic features of this part of the district. In the middle part of this southwesterly course Bear Creek flows for about 4 miles across a pronounced central basin that is inclosed by the two ridges. This inclosed basin is about 15 miles in length, its greater dimension extending in a northwesterly direction, somewhat transverse to the trend of the main valley. The greater part of this central basin area lies southeast of Bear Creek and forms a wide lateral expansion to the valley of the main stream that is drained by two of its longest tributaries—East Fork, about 9 miles long, and Myrtle Creek, about 7 miles long. The part of this basin

on the opposite side of Bear Creek is drained by Bonanza Creek, whose length is about 6 miles, and by Spruce and Happy creeks, each about 3 miles in length.

Where Bear Creek crosses the two mountain ridges above and below the expansive central basin along its middle course its valley is considerably constricted. The tributaries in these sections are relatively short and more gulchlike in character than those which drain the central basin.

UNCONSOLIDATED DEPOSITS.

The Bear Creek valley is occupied by widespread deposits of gravel and silt in the form of gently sloping and more or less continuous benches that extend along the entire length of the main stream and throughout the lower area of the expansive central basin drained by East Fork and Myrtle and Bonanza creeks. The main channel of Bear Creek and the lower courses of all its tributaries are more or less intrenched into these deposits to depths ranging in different parts of the valley from 10 to 100 feet or more. In general the amount of the intrenchment is progressively greater downstream, yet this condition is not markedly apparent at first glance because large quantities of the alluvial deposits formerly present along the immediate courses of the streams have been removed as the intrenchment proceeded, especially along the middle course of Bear Creek, where it flows through the central basin and where the alluvial deposits appear to have been deepest. Within this central basin the removal of unconsolidated material along Bear Creek has proceeded to a stage wherein this stream has reduced its flood plain almost to bedrock and for some time has been cutting laterally into the alluvial benches, thus forming a narrow strip of flood plain, from a quarter to half a mile in width, along its channel. The gravels of this flood plain range in depth from 3 to 8 feet and rest on a bedrock floor of fairly uniform grade.

Considerable amounts of coarse gravels and cobbles, with some bowlders, have been secondarily concentrated in this flood plain from the thick bench deposits as a result of their intrenchment, especially along the present channel of Bear Creek. Somewhat away from the present course of the main stream, in those parts of the flood plain that have not been reduced so nearly to the bedrock floor, the unconsolidated deposits appear to be composed more of finer gravel, together with sand and silt that do not appear to have been reconcentrated by the action of the present stream. At least, the larger part of the unconsolidated material somewhat removed from the present channel of Bear Creek is not so coarse as that along the channel. These finer sediments may be, at least in part, deposits that were laid down along the valley floor before the widespread bench

gravels were deposited throughout the valley. In other words, a considerable amount of the finer gravels and silts on the bedrock floor of the flood plain may represent the products of an older cycle of stream erosion in this valley that have not yet been affected by the secondary concentrating activities of the stream which are now intrenching and removing the thick bench deposits.

The greater part of the placer gold of this valley, so far as its distribution has been disclosed by prospecting and mining up to the present time, occurs in the gravels of the flood plain which have not been recently washed by the present stream and in the crevices of the shattered and decomposed bedrock upon which the gravels rest.

GOLD PLACER DEPOSITS.

DISTRIBUTION.

The most productive gold placer deposits so far found in the Bear Creek valley occur in the central basin and immediately above it. Most of the claims that have been prospected and worked are located as 20-acre tracts of the conventional dimensions—that is, approximately 1,320 feet in length and 660 feet in width. The longer dimensions of most of the claims extend along the course of the valley, but a few claims cross the trend of the valley in order to inclose more of the shallow gravel deposits.

The initial claim, designated Upper Discovery on Bear, is located just above the mouth of Myrtle Creek. Bonanza Creek empties into Bear Creek near the upper end of Upper Discovery claim. Downstream from this claim more or less prospecting and open-cut mining has been done on claims designated consecutively Nos. 1 to 6 below Upper Discovery. Upstream from it four claims, designated Nos. 1 to 4, above Upper Discovery have been mined to a considerable extent by open-cut methods. Several so-called bench claims located along the right margins of claims Nos. 1 to 6 below Upper Discovery include part of the shallow ground not covered by other locations.

A claim at the mouth of Bonanza Creek, designated Discovery claim for this stream, which immediately adjoins the claims along Bear Creek, has been worked in a profitable manner and may well be considered in connection with the shallow ground along the main creek, with which it is closely associated. Bonanza Creek is staked upstream from its mouth for several miles, but no productive mining appears to have been done within its valley above Discovery claim.

The only other ground on a tributary to Bear Creek in this part of its valley on which mining has been done is on Spruce Creek, a small stream discharging into Bear Creek on claim No. 4 below Upper Discovery, about 1½ miles below Bonanza Creek, on the same side of the valley. The alluvial deposits of Spruce Creek from its mouth to

its source are covered by eight claims, each of 20 acres, of which the one at the mouth is designated Discovery claim and the others Nos. 1 to 7 above Discovery. The only mining which has been done on Spruce Creek is represented by an open-cut working on claim No. 1.

Practically all the alluvial ground immediately along Bear Creek has been staked for placer mining and prospecting has been done as far upstream as claim No. 25 above Upper Discovery. A chain of 20-acre claims extends downstream from Upper Discovery for about 8 miles, or to the mouth of East Fork. Below East Fork, where the valley broadens as it leaves the higher mountains and passes through a belt of foothills, a more or less connected series of 160-acre association-group claims has been located. Altogether 10 or more of these association groups, each about 1 mile in length, are so arranged as to occupy about 8 miles of the valley bottom and the benches along the sides. Very little prospecting of a conclusive character has been done on these large tracts, but it is reported that prospects of gold may be obtained from some of their gravels, especially on rims of bedrock that are exposed here and there by the down-cutting of the main stream. The gravels on these bedrock rims may belong to the widespread bench-gravel deposits which fill the valley, but there is a strong possibility that they may be remnants of older stream gravels which have been buried by the bench gravels and recently exposed by the intrenching activity of Bear Creek. This may account for the opinion held by some of the prospectors that the bulk of the bench gravels on lower Bear Creek are poor in gold content. The only productive ground in this valley below the mouth of East Fork that has been worked to any extent is on a small tributary named Tiny Gulch, situated about 8 miles below Upper Discovery claim, on the left side of the main stream.

Except on the Tiny Gulch claims and on claim No. 1 above Discovery on Spruce Creek practically all the productive mining so far done in the Bear Creek valley has been confined to a tract about 3 miles in length, covered by the claims from No. 6 below to No. 4 above Upper Discovery, inclusive. The several so-called bench claims which adjoin claims Nos. 1 to 6 below Upper Discovery along the valley bottom may be included with the creek claims, as they are merely extensions of them. Discovery claim on Bonanza Creek may also be considered to belong essentially to the flood plain of Bear Creek, as it bears a close relation to the contiguous claims along Bear Creek at the confluence of these two streams. The features of this more or less productive tract may well be described without reference to the claim boundaries, because the gold-bearing gravel deposits which it contains have had the same history in all essential particulars.

CHARACTER OF BEDROCK.

The bedrock along the productive section of Bear Creek, defined above, is almost entirely obscured from view by the shallow gravels of the flood plain and the deep bench gravels which border the flood plain on both sides. Bedrock is exposed along the main creek at only a few points, where the stream flows strongly against the escarpments of the benches and has cut away their bases so as to form bluffs. In the lower part of several of these bluffs, especially in one on Upper Discovery claim, bedrock is laid bare in a slightly truncated outcrop beneath the thick bench gravels. To judge from this outcrop and the rather unsatisfactory exposures of bedrock floor that were observed in the few newly dug open cuts available for inspection during 1914, it appears that the dominant bedrock of Bear Creek within the productive area is a massive siliceous granitic intrusive rock. This rock is fine grained in texture and contains considerable biotite mica. It is somewhat decomposed and much fractured. Most of the igneous bedrock is broken into small angular fragments that may be readily loosened with a pick and lifted with a shovel, but some of it is in the form of larger blocks, a foot or more in dimension. These blocks and fragments are closely keyed together, and the innumerable crevices between them furnish spaces for the rapid circulation of water and the lodgment of particles of gold.

The massive granitic bedrock is in turn intruded by dark-colored dikes of diabasic rock which are softer and less fractured than the granitic rocks they cut, or rather the severe crushing to which they have been subjected is shown by mashing, distortion, and slickensided surfaces instead of by distinct, sharp-cut fracturing. Little can be determined in regard to the number and distribution of these dikes, owing to the widespread deposits of unconsolidated material on the bedrock. Small outcrops of the dikes, however, are encountered at frequent intervals in the open cuts on nearly all the claims that have been prospected or mined. Some of the exposures indicate a thickness of 10 to 20 feet for the larger dikes, but others show only a few inches of intruded material. The miners recognize these intrusives by their darker color and softer or tougher texture. Although the granitic bedrock is considerably decomposed, the dark dike rock is more so, and the surface portion of some of it has the consistency of hard clay. Bedrock of this kind appears to have been favorable for the retention of the placer gold in places where it has not been subjected to the strong scour of recent stream action; but in many places where such scouring has occurred it is quite barren of gold. It is much easier to dig and clean than the hard, fractured granitic bedrock, in whose crevices the gold lodges more beneath the surface.

In order to make a good recovery of placer gold from the shattered granitic bedrock the top layer of blocks must be pried apart, but as these blocks readily disintegrate into still smaller fragments the cleaning of the rock is tedious.

In taking up the shattered granitic bedrock considerable care must be exercised to exclude flowing water from the cuts as much as possible, for if water is allowed to flow through the crevices the sediment that fills them and holds the particles of gold is washed from the blocks, with the result that the gold immediately sinks into deeper crevices, from which its recovery by manual labor is almost impossible. In the most successful operations about 1 foot of the shattered bedrock is taken up, but in much of the mining that has been done no attempt was made to recover the gold in the bedrock and only the gravels were shoveled into the sluice boxes.

CHARACTER OF THE GRAVELS.

The gravel deposits along the present flood plain of Bear Creek from claim No. 6 below to claim No. 4 above Upper Discovery are from 3 to 8 feet in depth. In the distance of about 3 miles covered by these claims Bear Creek falls about 50 feet to the mile. The surface of the valley bottom back from the main channel of the stream also conforms in general to this average grade, though here and there it shows minor differences of level of a few feet. The average width of the flood plain is about a quarter of a mile. Although the slightly higher portions of the flood plain have the appearance of low benches and parts of them are located as so-called bench claims, prospecting has disclosed the fact that the gravels of which they are composed are in few places more than 6 feet in depth.

For the most part the surface of the narrow flood plain is bordered on each side by the abrupt but not particularly steep escarpments of the much deeper bench deposits into which the present flood plain of Bear Creek is intrenched. As is to be expected, however, there are here and there a few narrow tracts of intermediate benches, which lie between the higher benches and the lower surface of the shallow flood-plain deposits and evidently mark progressive stages in the development of the intrenched channel as it stands to-day.

The shallow deposits along Bear Creek are composed, for the most part, of well-washed gravels mixed with a small percentage of sand and clay. About a foot of silty soil has accumulated over the more stable portions of the flood plain, and in some parts sand and clay make up the bulk of the alluvial deposit, extending within about 1 foot of the bedrock floor, upon which is a layer of gravels.

The gravels are composed of the several kinds of rock that occur in the valley basin, the sandstone and hard shale or slate country

rock, the volcanic agglomerate and tuff associated with these sediments, and the siliceous and basic igneous rocks intruded into them. Most of the gravel is of the siliceous granitic rock, probably because its hardness makes it more resistant to wear. The gravel ranges in size from small pebbles to cobbles 6 to 10 inches in diameter. A few bowlders as large as 3 feet are present.

In general the deposits are rather loosely compacted—that is, the spaces between the gravels and cobbles are not tightly filled or sealed with sand or clay. As a consequence water circulates rather freely through the flood-plain deposits. The supply of water in Bear Creek is so abundant that all the unconsolidated deposits along the flood plain are more or less charged with it. Wherever open cuts are dug to bedrock a free seepage of water almost invariably appears in the excavations, and the low grade of the bedrock floor makes it difficult to construct satisfactory drains to carry the seepage water away from the working cuts. In addition to this the greatly shattered bedrock to a depth of several feet is also charged with a large volume of seepage water that circulates more or less freely. In many places this water appears to be flowing readily through open crevices and often it is under sufficient pressure to cause it to bubble perceptibly, like a small spring, from some of the crevices. Other crevices, however, are more or less sealed by fine sediment, and many of these clogged spaces contain fine particles of gold.

Evidently because of this extraordinary volume of free seepage water the gold-bearing deposits are entirely unfrozen throughout the year, a condition which is unusual for the interior of Alaska, where it is the rule for alluvial ground to be at least partly frozen. The occurrence of the placer gold chiefly in the gravels immediately on bedrock and in the crevices of the shattered bedrock would naturally be expected when consideration is given to the amount of water that flows through the deposits. Yet there is nothing unusual in this distribution of gold, as it is generally so distributed even in frozen placer deposits except where there has been more than one period of gold concentration in a cycle of drainage development.

In the valley of Bear Creek there appears to have been but one primary period of gold concentration—that is, only one period during which the conditions of direct stream erosion and concentration of the products of disintegration of mineralized bedrock were favorable for the formation of placer gold deposits along the present bedrock floor of Bear Creek. The evidence at hand favors the view that the placer gold now found along Bear Creek was concentrated there before the present bench deposits were laid down throughout the valley.

Three distinct periods of drainage development are recorded by the unconsolidated deposits in Bear Creek valley to-day. The record

of the oldest may be read in the bedrock form of the valley. It marks a time when the streams were eroding and concentrating the disintegrated bedrock and the gold of mineralized areas of the bedrock. The second period was that during which the valley basin was deeply filled by the alluvial deposits that now form the extensive high benches along the sides of the valley. During this period the streams were so heavily loaded with gravels and silts that concentration did not occur on bedrock, and such concentrations as were already there, as a product of the earlier drainage system, were deeply buried by the continued additions to the sediments, until they were built up to their maximum thickness. The third or youngest period of drainage development is the one which may be observed in the valley to-day. Its principal activity is the intrenchment of the present drainage courses into the thick alluvial deposits laid down during the second period. Although considerable quantities of these thick deposits are being removed in consequence of this intrenchment and coarse gravels from the removed alluvium are being concentrated along the trunk stream and its larger tributaries, this process does not involve a concentration on bedrock such as was effected by the drainage of the oldest period—that is, it does not involve the concentration of newly disintegrated bedrock along the immediate lines of intrenchment except in the few minor areas already cited, where small outcrops of bedrock have been exposed beneath the bench gravels at widely separated intervals along the immediate channel of Bear Creek. In brief, the present drainage development is not of the kind that might be expected to effect a concentration of gold from bedrock, because the bedrock is not being eroded and as a matter of fact has been protected from erosion since the first period of drainage development described above. The drainage of the present period has hardly incised its trunk course near enough to bedrock to have any influence on it whatever. For these reasons the second and third periods of drainage development in Bear Creek valley are considered to have played a very minor part in the concentration of the placer gold now found along the bedrock floor of the valley. In other words, the gold concentration is considered to have occurred almost entirely if not altogether during the first period of drainage development.

The chief facts supporting this argument for only one period of gold concentration in Bear Creek valley may be summarized as follows: Placer gold is produced primarily at stages of drainage development when the streams are concentrating disintegrated rock from mineralized areas. The Bear Creek valley has just passed through a period of drainage development during which its bedrock was not being eroded, but on the contrary was being covered deeply with

unconsolidated sediments. Although the present streams have recently begun to erode again, the down-cutting has barely reached the stage where the streams are working near the bedrock floor of the valley and has not yet brought about a condition in which they could make any primary concentration of gold from bedrock. Neither do any of the present large tributaries to Bear Creek appear to be now contributing an appreciable amount of placer gold to the main creek, along which the richest deposits occur. If such a process of enrichment were now in progress, one or more of the larger tributaries to the productive section of Bear Creek should contain gold in proportion to the deposits along the main stream, but this does not appear to be the case.

The only alternative supposition to account for the gold now found along Bear Creek is that which assumes that the gold is derived, by secondary concentration, from the thick bench deposits during the progress of their intrenchment. This supposition does not appear to be satisfactory, because if such were the derivation of the gold it would be natural to expect a proportional distribution of gold along at least some of the intrenched tributaries to the productive section of Bear Creek, which might have acted as an agency of enrichment to the deposits along the main stream, but evidence that the gold had a widespread distribution throughout the bulk of the bench deposits is lacking. At least the outwash character of the bench deposits appears to preclude the possibility that placer gold has been concentrated in particular tracts within them and not in others. The coarser constituents of the bench alluvium show uniform concentration by the down-cutting of both the main stream and its tributaries; consequently it should be expected that placer gold derived from the same source should also be concentrated more or less uniformly along the intrenched stream channels if it were present in the bench deposits with the gravels. As the placer gold along Bear Creek and its tributaries seems not to be uniformly distributed, the only conclusion that appears to satisfy the facts as now known is that the gold has no essential connection with the thick bench gravels or their intrenchment, but is closely related to the period of stream erosion and concentration that preceded the deposition of the thick alluvium of the benches. In other words, the placer gold appears to belong to the oldest period of drainage activity of which there is a record in the Bear Creek valley. This conclusion is more significant when the glacial outwash character of the bench deposits is considered, as will be described below.

The gold now found along Bear Creek occurs on both sides of the present channel, as if the stream in its meandering had cut through what may previously have been a more or less continuous pay streak

belonging to an older concentration and thus, by removing the gold-bearing gravels here and there, had produced the somewhat barren spaces that the miners term "blanks." As has been stated, the greater part of the placer gold of this valley occurs in tracts of gravels and shattered and decomposed bedrock that have been least disturbed by the present down-cutting of the stream to, or nearly to, the bedrock floor. Furthermore, the gravels with which the gold is most closely associated appear to be finer and more oxidized than the general run of coarser gravels that have been reconcentrated from the bench deposits.

From the preceding discussion it may be easily understood that the concentration of placer gold along Bear Creek has not had a simple history, but one of many complexities. As one of the chief episodes of this history is that which introduced the thick bench deposits, a description of these deposits is given below.

BENCH DEPOSITS.

The escarpments of the dissected benches which border the present flood plain of Bear Creek are for the most part abrupt, but not particularly steep except where they are now being eroded by the creek as it meanders from one side of its flood plain to the other. Beneath the thick bench gravels in a few of these steep, freshly cut bluff banks are exposed slightly truncated outcrops of bedrock, which indicate something of the gently rolling configuration of the floor upon which the bench deposits rest.

The evidence that the unconsolidated deposits of gravels and silts in the central basin of the Bear Creek valley were formerly much thicker than they are now is furnished chiefly by the margins of these alluvial deposits against the bedrock slopes that border this central basin. These margins are distinctly indicated where the gently sloping surfaces of the alluvial benches abut against the steeper bedrock slopes along the flanks of the mountain ridges and spurs, especially between the larger tributaries, where they have been protected from removal by recent erosion. For example, on the broad bedrock spur between Bonanza and Spruce creeks the upper margin of the alluvial bench stands fully 400 feet above the present flood plain of Bear Creek at the mouth of Myrtle Creek, and on the slopes of the main valley on each side of Happy Creek, opposite the mouth of East Fork, remnants of alluvial benches stand fully 500 feet above the main creek. South of Bear Creek the area between East Fork and Myrtle Creek, which discharge into Bear Creek at points about 3 miles apart, is entirely occupied by an alluvial bench. The surface of this broad bench slopes gradually up toward a mountain spur that stands about 3 miles south from Bear Creek. On the flanks of this spur the margin of the alluvial deposits stands at an eleva-

tion of over 500 feet above Bear Creek, which is somewhat higher than the margin of the bench deposits on the north side of the valley, between Bonanza and Spruce creeks. The upper limits of the alluvial bench deposits in the more constricted sections of the Bear Creek valley stand at the same general level as those within the central basin.

The general accordance of level of the margins of these widespread alluvial deposits along the main valley of Bear Creek and throughout its central basin appears to point to the conclusion that this valley was formerly filled with alluvium nearly, if not quite, to the height indicated by the margins of the present benches. At least the alluvial filling was much deeper than at present, for the upper limits of such deposits are clearly of the type that was controlled by one stage of stream aggradation. This view necessitates the conclusion that the surface upon which the alluvial deposits were spread, when they reached their maximum development, must have extended across the whole area of the central basin and up and down the main valley of Bear Creek at the elevation indicated by the present marginal limits of the alluvial deposits. In other words, the evidence of the present benches indicates that practically the whole area of the Bear Creek valley, with the exception of its headwater basin, was filled with unconsolidated gravels and silts, which at the mouth of Myrtle Creek reached a maximum depth of at least 400 feet and at the mouth of East Fork a depth of about 500 feet.

The surface on which the streams were depositing this material was, without doubt, a progressively rising or aggrading one until the maximum thickness of the alluvial deposits was built up. Since then the process has been reversed, and there has been a progressive lowering of the surface during which a considerable bulk of the alluvial deposits has been removed, or ground-sluiced, from the central basin; and the main stream and its principal tributaries have intrenched their channels.

It is obvious that the drainage conditions under which Bear Creek valley was filled with gravel and silts, especially in its extensive inclosed central basin, must have been entirely different from the present conditions, under which that material is being gradually removed. A sufficient cause to account for these conditions, however, is found close at hand, in the part of the central basin that is drained by the upper 6 miles of East Fork, where there are distinct and strong evidences of mountain valley glaciation.

GLACIATION ALONG EAST FORK.

The sources of East Fork occupy a distinct glacial cirque whose steep walls have been eroded in the north flank of Mount Plummer. This summit has an altitude of about 4,600 feet, and the bottom of

the cirque is about 2,000 feet below the summit. The point of discharge of East Fork into Bear Creek, about 9 miles from its source, is fully 2,000 feet lower than the bottom of the cirque. Thus the part of the central basin drained by East Fork has a steep gradient, which is ample to permit the discharge of a large quantity of alluvial material into the Bear Creek valley when conditions are favorable for the erosion of such material from the mountains.

The upper 6 miles of the East Fork Valley is now occupied by extensive glacial moraines, which give proof that the mountains bordering this part of the central basin have been subjected to profound erosion. These morainal deposits are composed chiefly of large bowlders, which for the most part have a typically disorderly arrangement, with many potholes and other characteristic glacial features. Some of the potholes hold lakelets and ponds. A group of such lakelets occurs about 6 miles from the source of East Fork, or 3 miles from Bear Creek, at an elevation of about 400 feet above the main stream, approximately at the margin of the broad bench which extends between East Fork and Myrtle Creek. These lakelets appear to mark the site of a well-developed terminal moraine that was deposited by the glacier which formerly occupied East Fork.

Without going into details it may be stated that a glacier at least 6 miles long formerly occupied the upper valley of East Fork and is believed to be a cause sufficient to account for the amount and character of the alluvial bench deposits that now occur throughout the valley of Bear Creek. At its maximum development the East Fork glacier may have reached quite to the mouth of East Fork and thus dammed the whole valley of Bear Creek above that point. On the other hand, such damming of the Bear Creek valley as is necessary to account for the alluvial benches throughout its extent may have been caused by outwash gravels, which were discharged in such large quantities from the glacier's terminus, near the group of lakelets mentioned above, as to effectually clog the valley above East Fork. In either case it is apparent that the Bear Creek valley was filled with outwash gravels and silts, chiefly of glacial derivation, up to the marginal limits of the present widespread benches; and it is also apparent that much of this material has been removed since the melting of the East Fork glacier.

EFFECTS OF GLACIATION ON PLACERS.

The processes of glacial erosion and deposition are very unfavorable to the formation of placer deposits—indeed, they are generally considered to be destructive of such concentrations. Placer deposits of value are not to be expected in areas that show evidences of having been directly eroded by glacial ice unless there has been in such areas

a period of stream erosion upon mineralized bedrock since the ice disappeared. Any placer concentrations that might have existed in such areas before the glaciation will have been almost invariably scoured away and scattered broadcast in the sediments outwashed from the glaciers by their melting waters. Gravels and silts deposited by heavily loaded glacial streams, beyond the areas eroded by ice, are not to be expected to concentrate placer gold; for usually such deposits are built up so rapidly by dumping of material in unassorted arrangement as to preclude the processes of stream concentration. On the other hand, however, outwash sediments of this character may be expected to bury previous placer concentrations and thus protect them during the period of active glaciation and long enough afterward for the stream drainage that may succeed the glacial drainage to remove the overburden of glacial outwash deposits.

Although the upper basin of East Fork is occupied by considerable masses of intrusive granitic rock, there is no evidence at hand to prove that the glaciated part of this basin contains rocks mineralized with gold. The evidence that placer gold was deposited in appreciable amounts with the glacial outwash sediments that now form the widespread benches throughout the Bear Creek valley is also negative, as has been considered on pages 314–318.

There is, however, one locality in the Bear Creek valley, on Spruce Creek, where some placer gold appears to have been concentrated in the glacial outwash sediments either during the period of their deposition or during the succeeding period of intrenchment and removal. Nevertheless the chief concentration of gold in Spruce Creek appears to have taken place on its bedrock floor during the period of erosion and concentration that preceded the period of glacial activity. Although the manner of occurrence of some of the gold on Spruce Creek appears to indicate concentrating activity at intervals throughout all three periods of erosion and deposition now recorded by the unconsolidated deposits in the Bear Creek valley, this locality seems to be characterized by special features not found in the valley as a whole. These features are pointed out below.

SPRUCE CREEK.

Spruce Creek is a small tributary, about 3 miles long, that discharges into Bear Creek from the northwest about 1½ miles below Bonanza Creek. Its valley consists of upper and lower sections of quite different character. Its upper mile drains a bedrock basin eroded from a steep mountain spur whose crest stands about 2,000 feet above the mouth of the creek. The stream descends fully 1,500 feet in this distance of 1 mile. In the lower 2 miles the valley is eroded in the bench deposits that are distributed throughout the central basin of Bear Creek. In this lower section the stream has a descent of about 400 feet and does not flow on bedrock at any point.

The erosion of the lower 2 miles of Spruce Creek has removed a large amount of the thick bench deposits, but on the left a well-preserved area of these sediments, 1½ miles broad, extends to Bonanza Creek as a gently sloping bench. There is also a narrow bench of these sediments along the right side of lower Spruce Creek. The upper limits of these bench deposits, on both sides of Spruce Creek and up its valley, stand at approximately 400 feet above the present flood plain of Bear Creek at the mouth of Spruce Creek. From the uniform level of the upper limits of the bench deposits in and about the Spruce Creek valley, and in fact around the entire border of the central basin of the Bear Creek valley, it appears that these sediments attained a thickness of about 400 feet at the present mouth of Spruce Creek at the time of their maximum accumulation. Whether this deep filling really occurred or not, there is ample evidence to show that in the lower 2 miles Spruce Creek has eroded a large quantity of unconsolidated sediments from its valley during the last or intrenchment period of drainage development of Bear Creek and its tributaries. Spruce Creek, being one of the minor tributaries to Bear Creek, is not to be expected to show as thorough intrenchment of the bench sediments within its valley as the trunk stream and its larger tributaries. The result is that a considerable thickness of unconsolidated sediments still remains along the bottom of the lower section of the Spruce Creek valley. For instance, at a point about 1,500 feet above the mouth of the creek the sediments that occupy the valley are at least 20 feet in depth. This depth of sediments is disclosed in an open cut about 280 feet long and 15 to 20 feet wide situated on the lower part of claim No. 1 above Discovery on Spruce Creek. This development work was commenced in 1913 and continued during the summer of 1914 with the labor of about six men. The trench is designed as a bedrock drain. Its upper end, which is 280 feet from the place where it was begun, is 15 feet below the surface. A pipe driven into the sediments at this point indicates the bedrock floor of the valley to be about 5 feet deeper than the trench, or 20 feet below the surface.

An average section of this cut shows from 2 to 4 feet of vegetable muck as a surface layer. Below this muck is from 2 to 3 feet of coarse gravel that contains occasional bowlders as much as 1 foot in diameter. These bowlders are of granitic and agglomerate rocks, and the gravels are made up of the same kinds of rock, together with pebbles of hard sandstone and shale. Beneath these gravels is a layer of bluish clay, from 1 to 1½ feet thick, of the kind that is characteristic of glacial sediments. The deposit below the blue clay is a brown sandy clay with pebbles. It is believed that sediments of this character extend to bedrock.

Several thousand dollars' worth of gold has been mined from the sediments of this cut by washing them through a line of small sluice boxes as the work of excavation progressed. Those who have done this work believe the brown pebbly clay in the bottom part of the cut to be a sort of false bedrock, or, rather, they have found that much of the placer gold occurs above the lowermost sediments and that the best concentration appears to occur on or in the layer of blue clay. Nevertheless gold to the amount of 1 cent to the pan is reported to occur in the brown pebbly clay so far as it has been prospected, and it is thought that good concentrations of gold should occur on the bedrock beneath this clay. Some gold occurs in practically all the sediments, from the layer of muck on the surface to the bottom of the cut.

The washing of the gold from both the blue and the brown clay is difficult because of their tendency to form lumps or balls in the sluice boxes unless thoroughly disintegrated with water; and as the water supply of Spruce Creek is not ample, even for so small an operation, considerable delay was experienced both from the clay and from the accumulation of tailing gravels at the lower end of the sluice, where it was often necessary to employ as many as three men spreading tailings in order to keep the boxes free.

The placer gold mined from this trench is fairly coarse and rough. Small nuggets, worth from 75 cents to $1, are not uncommon. Many of these have quartz attached to them, and the general character of the gold indicates that it has not traveled far from its bedrock source.

The men who made the open cut on claim No. 1 also located the upstream claims Nos. 2 to 6 above Discovery, but have done no development work on them; consequently nothing is known regarding the depth or character of the unconsolidated deposits of these claims except what may be inferred from the cut on claim No. 1. It is probable that the sediments do not exceed 30 feet in depth on any of these claims and that on the upper claims they become more shallow. Claim "No. 7 above" is also staked. These seven claims, together with Discovery claim, at the mouth of the creek, are each about 20 acres in area and of the usual length of a quarter of a mile; thus they cover the 2-mile section of the Spruce Creek valley that is eroded in the unconsolidated bench deposits. The upper mile of the creek does not appear to have been staked for placer mining, although it is reported that prospects of gold may be obtained from the rather meager accumulations of washed gravels which occur along this section.

The upper mile of Spruce Creek appears to have had a simple history; throughout its existence it has been eroding the disintegrated bedrock from the steep mountain slopes of its basin, concen-

trating this material along its bed, and delivering the stream-washed sediments to the more gently graded lower section of the valley. On the other hand, the history of sedimentation, erosion, and concentration along the lower 2 miles of the valley is somewhat complex in that the products of erosion from the steep headwater basin have not been delivered under uniform conditions of stream activity. Before the bench deposits filled the lower 2 miles of the valley the eroded material from its upper basin was, without doubt, deposited and more or less concentrated along the bedrock floor of the lower section in a normal manner. But upon the invasion of large quantities of bench-forming sediments into the lower section of Spruce Creek valley, apparently in greater part from sources outside of that valley, the stream-washed material delivered from the upper bedrock basin of Spruce Creek appears to have become incorporated with the thick bench sediments, as they were built up, in an unassorted manner and forming a minor part of the deposits as a whole. After the bench sediments ceased to be deposited within the lower valley the stream entered upon the period of intrenchment that has recently characterized all the drainage of the central basin of Bear Creek. During this period large amounts of the unconsolidated bench deposits have been removed and the valley has assumed the form it now presents.

Under the conditions of sedimentation and erosion here outlined it is evident that different kinds of water action have had an important influence on the manner of occurrence of the placer gold contained in the deposits along the lower 2 miles of Spruce Creek. In the absence of evidence to the contrary it may be assumed that all the placer gold in the Spruce Creek valley originated from bedrock within the rather small area of its present drainage basin and not from an outside source. The delivery of the placer gold appears to have been going on before, during, and after the building up of the bench sediments. Secondary concentration of the gold from the bench sediments that have been removed from the valley, together with additions from the upper bedrock basin since the period of intrenchment began, probably accounts for all the gold that occurs above the horizon of the blue clay in the unconsolidated sediments of the lower 2 miles of the valley.

The origin of the gold in the brown pebbly clay beneath the layer of blue clay is not so clear. The more oxidized condition of these brown sediments may mean that they were laid down before the thick bench gravels were introduced into the valley. As has been stated, the conditions of gold concentration on the bedrock floor of the valley beneath the brown sediments are not known at present.

It is possible that some of the placer gold on the bedrock floor of Bear Creek in the vicinity of the mouth of Spruce Creek is derived

from the Spruce Creek valley. This inference seems to be especially applicable to what appears to be older and finer gravels that lie beneath the coarser unoxidized flood-plain gravels along Bear Creek and that do not appear to have been disturbed by the recent erosion of that stream. These gravels may be closely related to the older sediments along the bed of Spruce Creek. Such a delivery of gravels and placer gold to the Bear Creek valley from a minor tributary like Spruce Creek could very well have occurred before the deposition of the bench sediments, but there does not appear to have been a favorable condition for such delivery since the invasion of this tributary valley by the thick bench deposits. As the benches were built up to progressively higher levels within the Spruce Creek valley the ability of the small stream to wash gravels containing placer gold to positions much beyond the upstream limits of the progressively rising flood plain was diminished, because the grade of the stream was materially lessened downstream from those limits. Therefore the sediments from the upper bedrock basin of Spruce Creek, together with any placer gold they may have contained, were doubtless incorporated with the bench sediments at successively higher positions up the valley during the accumulation of the bench-forming sediments, instead of being carried down the valley to positions they may have formerly reached along its lower course or beyond in the valley of Bear Creek.

During the period of removal and intrenchment that has succeeded the period of bench accumulation Spruce Creek has not been able to clear its valley of the bench deposits that filled its lower 2 miles and return to its bedrock floor along that section. Consequently any placer gold that may have been concentrated along its bedrock floor during the period that preceded the deposition of the bench sediments should still be there in a practically undisturbed condition. However, Spruce Creek has removed a large amount of the bench sediments and has effected considerable secondary concentration of those sediments during that process. The unoxidized gravels, with small bowlders and cobbles, that lie above the layer of blue clay probably represent the products of this secondary concentration. The placer gold that occurs above the blue clay is evidently also the result of this secondary concentration. It therefore seems probable that practically all the placer gold deposited along the lower 2 miles of Spruce Creek since the deposition of the bench sediments began has been more or less concentrated by secondary stream action within the area of the valley itself and has not enriched the placers of Bear Creek in any material degree.

Spruce Creek appears to be about the only tributary to the central basin of the Bear Creek valley that could have been a source of

some of the placer gold now found in Bear Creek—at least it is the only tributary so far discovered that contains gold in commercial amounts. The lack of placer gold in commercial amounts on the other tributaries is probably attributable to the character of the bedrock in which their basins are eroded—that is, it indicates that the bedrock of these tributaries is not mineralized with gold in appreciable amounts. In fact, the bedrock affording the most favorable conditions for gold-bearing mineralization, from which placer gold might be derived, appears to have a distribution that conforms somewhat closely with the area in which the placer gold deposits now occur. This distribution of placer gold within an area of bedrock that appears favorable for gold-bearing mineralization is one of the chief facts in support of the opinion, already expressed, that most of the placer gold now found along the main course of Bear Creek was concentrated in this part of the valley before the invasion of the glacial outwash sediments from East Fork. Conditions favorable for the concentration of placer gold from bedrock along the central course of Bear Creek have been practically lacking since the bench-forming sediments were introduced, because nearly all of the bedrock has been buried. Moreover, as the bench sediments were built up the gradients of the lower courses of all the streams tributary to the central basin of Bear Creek were so lessened that most of them were probably unable to deliver much of the sediment derived from their upper bedrock basins very far beyond the progressively rising upper limits of the flood-plain levels within the lower parts of their valleys. The result of such a condition of stream drainage would be that any placer gold that might be derived from the upper bedrock basins of the tributary streams during the period of bench accumulation would not have a favorable opportunity of being delivered beyond the limits of the valleys of such tributaries to positions along the present central course of Bear Creek. For this reason it does not seem probable that any large percentage of the placer gold now present along the central course of Bear Creek was deposited there by secondary concentration during the period of removal and intrenchment of the bench gravels. The fact that concentrations of placer gold of commercial importance have not been discovered along the larger tributaries to the gold-producing section of Bear Creek seems to indicate that the bedrock of those basins is not mineralized with gold in appreciable amounts. On the other hand, the fact that the character of the bedrock along the central course of Bear Creek, within the general area now occupied by the commercially valuable placers, appears to be entirely favorable for gold-bearing mineralization strengthens the view that the placer gold is essentially of local derivation.

CHARACTER OF BEDROCK.

The country rocks of the upper basin of Spruce Creek are composed of thick strata of agglomerate and fine-grained tuffaceous rocks interbedded with some sandstones and shales, all of which are well hardened and considerably fractured.

A large body of intrusive granitic rock cuts the country rocks near the head of Spruce Creek and forms the crest of the mountains to the south. Contact mineralization from this body of intrusive rock seems to be indicated in the country rocks of the Spruce Creek basin by small quartz stringers in the joint cracks. Some of this quartz is reported to contain gold, and the fact that placer gold attached to vein quartz is found in the creek is corroborative of this report.

On Discovery claim at the mouth of Spruce Creek a fine-grained granite rock that contains considerable biotite mica forms the bedrock in several prospect holes. It is probable that rock of this kind is the chief bedrock of this claim, and also of the claim upstream from it, where decomposed fragments of similar rock are reported to have been brought up by the pipe that was driven into bedrock in the open cut previously described. Rock of the same kind was observed on Discovery claim at the mouth of Bonanza Creek and forms a large part of the bedrock of the productive placer claims along Bear Creek between Spruce and Bonanza creeks and for about 1 mile above Bonanza Creek. The conclusion appears to be warranted that intrusive granitic rocks have a rather extensive and apparently continuous areal distribution beneath the unconsolidated bench deposits in that part of the Bear Creek valley where productive placers are now known to occur. It is not known whether the igneous rocks that lie beneath the bench deposits along the central part of the Bear Creek valley connect with the granitic intrusive body that crops out along the crest of the mountains south of the source of Spruce Creek, but it is thought that these intrusive bodies are closely related if not actually connected.

It may be that the mineralization from which the placers of Bear Creek are derived is intimately associated with the intrusive bedrock upon which much of the placer gold is now concentrated. The fact that the siliceous intrusive rocks along Bear Creek are in turn intruded by basic dikes may be of significance in this connection, for such relations are in many places associated with gold mineralization. Although vein quartz is not uncommon in the joint cracks of both the intrusive and the country rocks of this area, it is not developed in marked amount. The only indication of metallic mineralization with the quartz in the joint cracks that was observed in the placer-bearing area is on Discovery claim at the mouth of Bonanza Creek, where a thin quartz stringer showed discoloration by green malachite stains.

DEVELOPMENT AND PRODUCTION.

GENERAL CONDITIONS.

Since 1909 from 10 to 25 men have been engaged in mining and prospecting on Bear Creek. The actual mining has been done during the summer, but the unfrozen condition of the gravels has enabled some opening-up work and prospecting to be carried on during the winter. Most of the men, however, have been obliged to devote a considerable part of each winter to sledding their supplies for the year to Bear Creek from the trading posts of Bethel and Kolmakof, on Kuskokwim River. The distance by winter trail from Bear Creek to Bethel is about 115 miles and to Kolmakof about 55 miles. The trading post at Kolmakof was maintained only during 1912 and 1913, so most of the supplies used on Bear Creek have been obtained at Bethel. During the last several years freight has been hauled from Bethel to Bear Creek on sleds drawn by reindeer that belong to the natives. The charge for this haul is 5 cents a pound. The same charge has been made for hauling freight from Kolmakof with dog teams.

So far the production of gold from Bear Creek has not been sufficient to encourage the establishment of a supply station at or near the diggings. Such an enterprise should not be difficult to maintain if enough business should be offered. Shallow-draft steamboats can readily ascend Tuluksak River to a point about 30 miles above its mouth, near its junction with Fog River, and poling boats can be used for freighting supplies up the remainder of the river into the lower course of Bear Creek, within a few miles of the diggings. This water route has been used from time to time for transporting supplies with poling boats from Bethel to Bear Creek.

CHARACTER OF DEVELOPMENT.

All the placer mining on Bear Creek up to the present time has been done by simple open-cut, pick-and-shovel methods with small sluice boxes. The low grade of the stream has prevented the adoption of hydraulic methods except for small amounts of crude ground-sluicing to remove superficial accumulations of turf and soil. In 1911 a steam-power scraping and hoisting equipment was brought to Upper Discovery claim, but it has not been placed in operation.

Most of the excavations that have been made on Bear Creek are distributed along the 3 miles of the stream included in the claims from No. 6 below to No. 4 above Upper Discovery. Nearly all the ground so far demonstrated to be productive lies within this area along the main stream, with the exception of Spruce Creek, Tiny Gulch, and Discovery claim, at the mouth of Bonanza Creek. This

latter claim is in reality merely a lateral extension of the contiguous claims that lie along the main creek. Such work as has been done above and below this 3-mile tract is now practically abandoned, and the same statement applies to much of the work that has been done within this tract.

All the open cuts have been laid out in the form of bedrock drains or trenches, and many of them have not been developed beyond this form. In some places, however, where the gravel has given more promise of immediate returns, the trenches have been expanded laterally into excavations of considerable dimensions. The most extensive of these pits have been made on Upper Discovery claim, on claims No. 4 below, and Nos. 1, 2, 3, and 4 above Upper Discovery, and on Discovery claim at the mouth of Bonanza Creek.

PRODUCTION.

The value of gold that has been produced from the placers of Bear Creek during the six years of mining from 1909 to 1914, inclusive, is estimated by those in a position to judge to be about $35,000. Full data for the yearly production are not available.

It is reported that the value of the gold produced in 1909 was about $3,500. Most of this gold was mined from a small area on Tiny Gulch. The ground staked on Tiny Gulch comprises only two 20-acre claims, on which the gravels are from 2 to 3 feet in depth. Since 1909 the production from this ground has not been more than a few hundred dollars' worth each year. The value of the output in 1914 is reported to be about $650, and the total value of the gold produced from the two claims on Tiny Gulch during the period 1909–1914 probably does not exceed $5,000.

About $6,000 worth of gold was the average yearly production for Bear Creek from 1910 to 1913. Most of this gold was mined from the open cuts along the main stream, where the gravels vary from 4 to 8 feet in depth. An average of 40 to 50 cents' worth of gold to the square foot of bedrock is the best yield reported to have been obtained from the larger cuts, and much of the mining in these cuts has not yielded more than 20 cents to the square foot of bedrock. In most of these cuts, however, no particular effort seems to have been made to take up much of the shattered bedrock, in the crevices of which considerable gold is lodged, or to control the abundant flowage of seepage water in the cuts while the bedrock was being cleaned. In several operations where more care has been exercised in taking up the bedrock average yields of 30 cents to the square foot of bedrock have been obtained; and in one operation in which particular attention was given to saving the gold in the bedrock an average yield of nearly 50 cents to the square foot is reported.

During the greater part of the summer of 1914 from 12 to 15 men were engaged in mining on Bear Creek, and the total production was about $7,000 worth of gold. The largest number of men engaged on a single operation was six, on claim No. 1 above Discovery, on Spruce Creek. Several of these men were working for wages and received $10 a day without board. Most of the other men were working independently on their own claims or under layman agreements. Two operations were conducted by men working alone; another by two men working as partners on a lay; and a third by two men who owned the claim and hired another man to help.

PROPOSED DEVELOPMENTS.

In 1914 an improved type of portable prospecting drill, operated by gasoline power, was taken to Bear Creek with the object of testing the deposits for dredging. The men who contemplate dredging operations have purchased or bonded nearly all the placer ground along Bear Creek from claim No. 6 below to claim No. 3 above Upper Discovery. During 1914 the drill was used to test this ground, especially that part of the tract included in claims Nos. 1 to 6 below Upper Discovery. The results of open-cut mining that has been done on Upper Discovery claim and the two claims above it are considered to furnish fairly satisfactory data as to the gold content of the gravels on the upper part of the tract which it is planned to dredge. It is reported that a small dredge may be installed on Bear Creek within the next few years. The character of the gravels and bedrock seems to offer no difficulties to dredge mining. It appears that 10 feet is the maximum depth to which a dredge will have to dig in order to handle the gold-bearing deposits on Bear Creek effectually.

Steam power, with wood for fuel, has been considered somewhat favorably for operating a dredge on Bear Creek, but the supply of spruce timber readily available in the valley is not abundant. Most of the timber in this valley is situated downstream from the tract to be dredged, with the exception of a meager amount on the two lowermost claims of the tract, which is not adequate for the operation of a dredge for any great length of time. Consequently the hauling of wood from the lower part of the valley will be a considerable item of expense in operating a dredge with steam power. There is a possibility, however, of obtaining cheaper and more satisfactory power for dredging by installing a small hydroelectric plant on the East Fork of Bear Creek 3 or 4 miles above its mouth. The volume and grade of this stream appear to be ample for such a purpose.

CALIFORNIA AND GRANITE CREEKS.

California and Granite creeks are two streams of about the same length and volume as Bear Creek and, together with that stream, comprise the chief headwater tributaries of the northerly branch of Tuluksak River. (See Pl. XI, p. 350.) They are west of Bear Creek and empty into Tuluksak River from the north about 8 miles apart. California Creek, which lies about midway between Bear and Granite creeks, is by some considered to be the head of Tuluksak River and is so designated, the name California Creek being used in a more restricted sense for one of the tributary streams within this valley.

The valleys of California and Granite creeks are bounded by low mountains and foothills that lie in a broad belt west of the higher mountains that surround the valley of Bear Creek. The headwater basins of these two valleys are separated from the valley of Ophir Creek, to the north, by mountains from 2,000 to 3,000 feet in altitude. These mountains are made up chiefly of massive intrusive granitic rocks. It is reported that the greater part of the valley of Granite Creek is eroded from massive granitic rocks, hence the name of the stream. Rocks of this character are also reported to have a widespread distribution within the valley of California Creek.

Colors of gold are reported to have been found in both Granite and California creeks before gold was discovered on Bear Creek. In fact, it is stated by old-timers that the prospects found on these two creeks encouraged them to extend their search across the divide into the valley of Bear Creek. These men did not consider granite bedrock a good "formation" to prospect for gold. This opinion was probably held generally among Alaskan prospectors until the Iditarod placers were discovered.

The prospects of gold in the valleys of California and Granite creeks appear to be intimately associated with residual and stream-washed products of decay from the granitic rocks. Apparently there are in these valleys no complications of concentration caused by glaciation, such as exist in the Bear Creek valley. Under these conditions the residual granite sands and the stream-washed material derived from them should be worthy of further prospecting.

BOGUS CREEK.

Bogus Creek is a stream of minor size that flows by a tortuous course across the Kuskokwim lowlands about midway between lower Tuluksak River and Whitefish Lake. Its upper course drains part of the outlying foothills situated between Granite Creek and the Kuskokwim lowlands.

It is reported that colors of placer gold may be obtained from the stream gravels of this valley. About 10 years ago a prospecting shaft was sunk here to a depth of 50 feet, and the sediments were found to be frozen to this depth. Since then no further prospecting has been done in the valley. The prospectors who sunk the shaft on Bogus Creek also sunk a shaft to a depth of about 50 feet in frozen ground in the valley of Tuluksak River at a point about 5 miles below the mouth of Granite Creek. It is reported that fine colors of gold were found in both these shafts.

OPHIR CREEK.

LOCATION AND GENERAL FEATURES.

Ophir Creek is a stream of considerable volume, about 15 miles in length, whose source is in Rockpile Pass on the west flank of Mount Hamilton, north of Bear Creek, on the other side of the divide. (See Pl. XI, p. 350.) It flows in a direction somewhat west of north into Whitefish Lake, which is the largest of a chain of lakes and ponds in the Kuskokwim lowlands along the northern border of the foothills between Tuluksak and Aniak rivers. This large lake and Ophir Creek are about midway between the lower courses of the two rivers just named.

Rockpile Pass has an elevation of about 2,000 feet and Whitefish Lake of about 250 feet above sea level, consequently Ophir Creek descends about 1,750 feet in its length of about 15 miles. A thousand feet of this descent is in the upper 3 miles of the creek, where the valley is dominated by Mount Hamilton and its subsidiary spurs. For several miles below this steep upper section the creek falls about 200 feet to the mile and its valley is bordered on both sides by rolling mountain ridges about 1,500 feet in altitude. Thence to its mouth the grade of the stream gradually becomes less, the valley broadens, and the ridges on the sides gradually descend to gently sloping foothills that merge with the Kuskokwim lowlands.

Ophir Creek has no tributaries of consequence from the east and only three of any considerable length from the west. The uppermost of these is about 3 miles long and empties into the main creek about 4 miles from Rockpile Pass. This branch is of note chiefly from the fact that a hot spring is situated within its basin, about 1½ miles above its mouth, in consequence of which it is named Hot Spring Creek. This spring is of scalding temperature at its point of issue, but the water it discharges is cooled within a few hundred yards by mixture with surface water. It flows from a massive granitic intrusive rock that occupies a large area in the upper part of the basin of this tributary. Its waters do not appear to be mineralized; at least no sinter material is deposited about the spring.

The other two west-side tributaries to Ophir Creek are each about 4 miles in length and flow into it about 3 and 5 miles, respectively, below Hot Spring Creek. All three of these tributaries rise on a domelike mountain mass whose summit is about 2,800 feet above sea level. This is the highest mountain flanking the valley of Ophir Creek except those about its source.

The valley of Ophir Creek is in sharp contrast to that of Bear Creek in that it contains no glacial features. Glacial activity appears to have had no part in its development, which as a whole is that of normal stream erosion and deposition in a mountainous country of moderate relief.

CHARACTER OF BEDROCK.

The country rocks of the Ophir Creek valley consist chiefly of stratified volcanic fragmental material of basic composition interbedded with minor amounts of shale and sandstone. Much of the volcanic material is in the form of fine-grained and thinly bedded tuffs, but it includes members of considerable thickness made up of medium-textured agglomerate. All the country rocks are much hardened, and in some of the tuffs and shales slaty cleavage has been developed along the planes of bedding.

An extensive mass of granitic intrusive rock occupies the slopes and ridges of the west side of the Ophir Creek valley in its upper half. The basin of Hot Spring Creek is eroded mainly in this granitic rock, which also forms the domelike mountain mass drained by this stream and the two other larger tributaries of Ophir Creek. The hot spring previously mentioned is near the eastern border of the intrusive mass, where it is in contact with agglomerate country rock. This massive granitic intrusive extends southward from the basin of Hot Spring Creek across the divide into the valley of Bear Creek and thence farther south into the basin of Aniak River, as is described on page 338.

Besides the massive body of granitic rock there are dikes of the same kind cutting the country rocks about the head of the valley, especially in the flanks and subsidiary spurs of Mount Hamilton. Several dikes of andesitic rock cut the stratified volcanic country rocks on the east side of the valley of Ophir Creek about the middle of its length.

UNCONSOLIDATED DEPOSITS.

The change in the grade of Ophir Creek is directly reflected in the character of the stream-washed deposits along the valley bottom. In the upper 5 miles of the valley the greater proportion of the unconsolidated deposits are coarse gravels and cobbles. A number of bowlders of moderate dimensions are also present, especially toward

the head of the creek. Downstream from this section of coarser wash the stream gravels become progressively finer, and along the lower half of the valley silts make up a large part of the stream deposits, although fine gravels occur in the present bed of the stream all the way to its mouth. The flood-plain deposits along the lower half of Ophir Creek have the form of wide, low-lying, swampy tracts. The surface of this lowland stands only a few feet above the normal stage of stream flow, and during floods it is extensively inundated. The banks of the main stream throughout the central section of the valley are only a foot or two high, and consequently this part of the flood plain is also subject to overflow. In brief, Ophir Creek is essentially an aggrading stream, flowing upon and building up its flood plain from its mouth to its source. Apparently the stream has had this character throughout its recent history, at least. Possibly this is the reason why the gold in its gravels is not well concentrated but rather widely distributed.

There are no well-developed bench deposits, in the real sense of the term, along the valley of Ophir Creek—that is, there are no deposits that have been laid down by the main stream at a higher level and then intrenched by it. The only sediments that bear the relation of benches to the present flood plain are gently sloping alluvial-fan deposits that have been discharged into the main valley from short gulches along some parts of the central section of the valley. Where these lateral gulches are close together the sloping-fan deposits from them coalesce with one another and give the appearance of benches, especially where the meanders of Ophir Creek are now cutting into them. These so-called bench deposits are frozen for the most part, but nearly all the unconsolidated sediments along the flood plain are unfrozen.

GOLD PLACER PROSPECTS.

It is reported that gold was discovered on Ophir Creek by some of the men who participated in the "Yellow River stampede" during the winter of 1901–2. The prospects were merely fine colors obtained from shallow holes made with wood fires. Although claims were staked at that time no serious prospecting was undertaken, as none of the parties had outfits adequate to enable them to remain in the district.

Ophir Creek does not appear to have attracted further attention from prospectors until 1913. In that year a dozen or more prospectors located claims along the course of the stream for a distance of about 10 miles. These claims extend from a point about 4 miles above the mouth of the creek to a point near its source. In upstream order the principal claims are designated Lower Discovery, Nos. 1 to

12 above Lower Discovery, Nos. 6 to 1 below Upper Discovery, Upper Discovery claim, and Nos. 1 to 8 above Upper Discovery. Most of the claims are 20 acres in area, but some of them are association-group claims of 40 acres.

Most of the men who located claims on Ophir Creek in 1913 came prepared to remain throughout the winter. As a result half a dozen cabins were built and considerable serious prospecting was done. This work was fairly well distributed along the creek, and consequently a good idea of the nature of the alluvial deposits has been gained. Sufficient prospecting has not yet been done, however, to warrant a definite statement as to the value of the gold content in the gravels, though it seems to have been demonstrated that fine gold is somewhat generally distributed along the creek.

The presence of free seepage water in the unfrozen gravels along the flood plain prevented the successful sinking of holes to bedrock on the larger part of the creek claims, but a number of holes were sunk to bedrock in the frozen deposits on both sides of the creek, and two open trenches, or bedrock drains, were dug at places where the gravels were shallow enough for this kind of prospecting.

On Lower Discovery claim a hole 23 feet in depth was sunk to bedrock. It is reported that about 7 feet of sediment at the bottom of this hole prospected about half a cent to the pan.

Another hole about 38 feet in depth was sunk through gravel which is said to have prospected colors through the entire thickness of the deposit with the exception of about 2 feet at the top. This hole is the deepest on the creek.

On claim No. 6 above Lower Discovery a trench intended for a bedrock drain but not carried to bedrock was dug in the flood-plain gravels to a depth of about 3 feet. Colors of gold are said to have been obtained from the gravels of this excavation.

Prospects of 1 cent to the pan are reported to have been obtained from seven or eight holes that were sunk to a depth of 5 or 6 feet on claim No. 7 above Upper Discovery. None of these holes reached bedrock, however, for seepage water was encountered at the depth indicated.

On claim No. 5 below Upper Discovery a hole 14 feet deep was sunk in frozen ground on the right side of the creek. Bedrock was not reached at this depth, but colors of gold are reported to have been obtained.

On Upper Discovery claim a trench 150 feet in length was dug as a bedrock drain and was 7 feet below the surface at its upper end. Colors of gold were panned from this trench, and a drill hole, 5 feet in depth, was driven at its upper end to bedrock, which is thus shown to be about 12 feet beneath the surface of the flood plain at this point.

Prospects of several cents to the pan are reported to have been obtained from this drilled hole.

Two holes were sunk in frozen ground on claims Nos. 3 and 4 above Upper Discovery and encountered bedrock at a depth of 15 feet. A drill hole was made in thawed ground which encountered bedrock at about the same depth. No report as to the prospects that may have been found in these holes was obtained. The same statement applies to claim No. 6 above Upper Discovery, where a hole was sunk in frozen ground to a depth of 22 feet without reaching bedrock.

No prospects of gold have been obtained from Hot Spring Creek, but it is reported that shallow pits on the two other west-side tributaries to Ophir Creek have yielded prospects.

From the work that has been done on Ophir Creek it appears that, owing to the large amount of wet unfrozen ground along the creek, prospecting with a drill should be the most satisfactory method of determining whether the deposits of this valley are of commercial value or not. Drilling was attempted during the winter of 1913–14. The most essential parts of a drill outfit were sledded to Ophir Creek from Bear Creek, where the machine had been operated with steam power the previous year. Several joints of 4-inch casing 5 feet in length, two heavy bits, and a bailer were assembled with the intention of drilling holes by hand. This outfit proved somewhat heavy for effective hand drilling, and most of the time of those interested was consumed in devising a portable drill tower provided with mechanical arrangements for increasing the power of the drill. Inadequate facilities prevented the successful accomplishment of this undertaking and consequently very little actual drilling was done.

From what has been learned of the depth and character of the unconsolidated deposits along Ophir Creek dredge mining would appear to be the method most applicable to the exploitation of the gravels providing they prove to contain sufficient gold.

Ophir Creek is somewhat favored as regards the transportation of heavy mining equipment and supplies, for the water route from Kuskokwim River to Whitefish Lake is available if the proper kind of boat is used. It would be less difficult to place a small dredge on Ophir Creek than on the other placer creeks now known in the district, because tedious and expensive overland hauling would not be necessary.

DOMINION AND ROBIN CREEKS.

LOCATION AND GENERAL CONDITIONS.

Dominion Creek, a stream about 10 miles in length, flows southeastward into Salmon River from the high mountains that stand

between its sources and those of Myrtle Creek and East Fork of Bear Creek. (See Pl. XI, p. 350.) The chief headwater basin of Dominion Creek lies on the eastern flanks of Mount Plummer, on whose northern flanks East Fork has its source. This headwater basin has been glaciated, like that of East Fork, although not to so great an extent. There is no question, however, that a considerable body of ice occupied the upper portion of this branch of Dominion Creek during the time when the East Fork glacier was in existence. The ice mass on the Dominion Creek side of Mount Plummer appears to have extended down the valley a mile or more at the time of its maximum development. Its limits are marked by morainal heaps of rock débris. The remainder of the valley bottom is occupied by outwash deposits of gravel and silt which extend to its confluence with the valley of Salmon River, whose bottom is also occupied by extensive alluvial deposits. The outwash deposits along the lower 4 or 5 miles of Dominion Creek are being intrenched by the present stream.

About 3 miles above the mouth of Dominion Creek, its chief tributary, named Robin Creek, enters from the west. Robin Creek is about 5 miles in length. Its upper part, 1 mile long, has a northerly direction and its lower part an easterly direction. The headwaters of Robin Creek occupy a steep basin on the northern flanks of the highest mountain in the district, Marvel Dome, whose altitude is about 4,800 feet. This basin is clearly a glacial cirque and is similar in all respects to the glaciated basin at the head of East Fork of Bear Creek, on the northern slopes of Mount Plummer. The northern slopes of both Mount Plummer and Marvel Dome appear to have been the most favorable situations for the development of glacial conditions in this district, but, although glaciation has also occurred to some extent on their eastern slopes, no glaciers were formed on the southern slopes. The significance of the differences in the character of erosion and stream deposition that have resulted from the presence or absence of glaciers will be pointed out later.

The floor of the glaciated headwater basin of Robin Creek is occupied by considerable morainal débris. Other evidences of the former occupation of this basin by a considerable body of glacial ice are also present. From this evidence it appears that the ice extended down the valley at least 2 miles and possibly farther. The remainder of the valley bottom is deeply mantled with heavy glacial outwash material, much of which is in the form of bowlders. These outwash deposits merge with those of the Dominion Creek valley. The lower 2 miles of Robin Creek is intrenched into them, in accordance with the intrenchment along the lower course of Dominion Creek.

CHARACTER OF BEDROCK.

The basins of Dominion and Robin creeks are almost entirely occupied by a series of interbedded sandstones and shales. The only other rocks known to occur within the area drained by Dominion Creek and its tributaries are granitic intrusives that cut the sedimentary series. These intrusive rocks appear to be distributed in a more or less continuous belt along the high crest of the divide that borders the drainage basin of Dominion Creek on the west, extending from Mount Plummer on the north to Marvel Dome on the south. Although the greater part of this divide is composed of sedimentary rocks, the harder granitic rocks define the serrated crest because of their greater resistance to erosion.

The sedimentary rocks cut by the granitic intrusives along this divide are considerably hardened along the zones of contact, the sandstones being altered to quartzites and the shales to slates. These altered sediments are much fractured and more or less veined with quartz stringers. Although no metallic mineralization was observed in the quartz veins, it may be presumed that some of them contain gold, at least on the southern slopes of Marvel Dome, where productive placers appear to have been derived from their disintegration and erosion.

GOLD PLACER PROSPECTS.

The lower 5 miles or more of Dominion Creek and the part of Robin Creek from its confluence with Dominion Creek to its moraine-filled headwater basin have been staked for placer mining, but very little systematic prospecting has been done in these valleys. It is reported that colors of gold may be obtained from the gravel deposits near the mouth of Dominion Creek.

In the vicinity of claim No. 3, below Discovery, on Robin Creek, which is about a mile above its mouth, several cabins have been built and some prospecting has been done, but no mining has yet been undertaken. The prospects of gold that have been found along this creek indicate that it is widely scattered. This does not appear strange in view of the character of the coarse bowlder-bearing glacial outwash deposits along Robin Creek, and especially of their unassorted condition and their deposition by torrential waters. Bowlders from 1 foot to 5 feet in diameter are very numerous in the unconsolidated deposits of this valley, particularly along the narrow flood plain of the present stream, where more or less secondary concentration has taken place during the recent intrenchment. Because of these conditions the unconsolidated deposits are difficult of exploitation and do not appear favorable for placer mining. At least they are unfavorable to mining if ordinary manual methods

are employed, even if they should be demonstrated to contain considerable gold.

Prospectors were led to investigate Robin Creek in particular because of the fact that its headwater basin is eroded from the belt of intruded and altered sediments that passes through Marvel Dome. It was reasoned that if such bedrock relations produced placers of value in the valley of Marvel Creek, on the southern flanks of Marvel Dome, the same relations at the source of Robin Creek, on the northern flanks of this mountain mass, should have produced the same results. It is possible that this reasoning is correct, but the prospectors failed to recognize the fact that the valley of Robin Creek has been affected by glaciation, while that of Marvel Creek has not been glaciated to any appreciable degree. It is obvious that the presence or absence of glaciers which effects the character of erosion and stream concentration on the opposite slopes of a mountain mass, such as Marvel Dome, has also a direct effect on the concentration of placer gold from mineralized areas within the mountain mass.

EUREKA CREEK.

Eureka Creek, which drains the eastern flanks of Marvel Dome, is about 6 miles in length, flows eastward, and empties into Dominion Creek, about a mile from Salmon River. It appears to have many of the characteristics of Robin Creek. Its source is in a steep basin on the eastern slopes of Marvel Dome, separated from the headwaters of Robin Creek by a typical glacial arête. This basin is eroded from the area of altered sedimentary rocks and granitic intrusives already described as forming the central mass of Marvel Dome. The unconsolidated deposits within the basin appear to be of glacial character and the lower valley is occupied by outwash sediments of the same character as those along the valleys of Dominion and Robin creeks.

Small prospects of placer gold are reported to occur in the gravels along parts of the valley of Eureka Creek, where a number of claims have been located, but no mining has been done on them. The remarks made regarding the possibilities of mining on Robin Creek seem to be applicable to Eureka Creek.

MARVEL CREEK.

LOCATION AND GENERAL FEATURES.

Marvel Creek is a stream of moderate volume which flows southward from Marvel Dome about 6 miles into Eagle Creek, which is tributary to Salmon River from the west. (See Pl. XI, p. 350.) The mouth of Marvel Creek is about 2 miles above the mouth of

Eagle Creek. On the east the valley of Marvel Creek is separated from that of Salmon River by a broad mountainous ridge whose rounded summits stand about 3,000 feet above sea level. On the west it is separated from the upper valley of Eagle Creek by a similar ridge. Both these ridges may be considered as southward spurs of Marvel Dome.

The comparatively narrow valley floor of Marvel Creek lies from 1,000 to 2,000 feet below the summits of the ridges, and the valley slopes rise with moderate steepness to the summits, which lie about a mile distant from the creek on both sides. Thus Marvel Creek has no tributaries more than a mile in length.

CHARACTER OF BEDROCK.

The country rock of the Marvel Creek basin appears to be a series of interbedded sandstones and shales similar to the sediments that occur in the basin of Dominion Creek, to the north. The only other rocks observed are the granitic intrusive bodies that cut these sediments in Marvel Dome. In the headwater basin of Marvel Creek there appear to be two masses of granitic rock cutting the sedimentary formations. These extend in a northwesterly direction through the higher mass of Marvel Dome and lie along both sides of the chief headwater branch of Marvel Creek. Along the course of the creek, between these bodies of granitic intrusives, there extends a mass of the sedimentary country rock, which has been considerably hardened and now has the form of blocky fine-grained quartzites and hackly slates. The bodies of intrusive rock appear to terminate in the rugged southeastern spurs of Marvel Dome. No traces of intrusives were observed south of these high spurs in the sedimentary rocks that extend from them and form the rounded ridges bordering the valley of Marvel Creek for 5 miles from its headwater basin. Although the sandstones and shales of these ridges are for the most part well hardened they show no evidences of mineralization from intrusive rocks. Between and near the granitic intrusive bodies, however, considerable contact alteration has occurred. The sedimentary rocks between the two granitic bodies show the greatest alteration, being hardened to dark-gray quartzites and black slates. Several rusty-reddish zones of weathering or oxidation extend through this belt of altered sediments, especially along and near the contacts with the intrusives. No other evidences of mineralization are discernible except a few quartz veinlets.

The sandstones and shales along the outside contacts of the granitic masses are also hardened to quartzites and slates, or the intermediate varieties of such altered sediments termed argillites and phyllites.

The strongest effects of contact-zone hardening die out a short distance away from the granitic intrusives. The hardened sediments of these outer contact zones are considerably fractured into blocks, and the fracture spaces are sealed with vein quartz in the form of irregular stringers. Most of these quartz stringers range in thickness from that of a knife blade to several inches, but a few of them are 8 to 10 inches thick. The largest quartz stringers are distributed along the east flank of the easternmost granitic body, where they show most prominently in freshly broken talus blocks of a more massive member of the sandstones that is coarser grained and less hardened than most of the other sediments near the granites. The quartz is of the glassy porcelain-white variety commonly termed "bull quartz" by prospectors. None of the vein quartz shows appreciable traces of metallic mineralization of any kind beyond red, iron-stained films here and there along fractures, due to surface weathering. All the quartz is surprisingly devoid of traces of sulphide mineralization. However, in the absence of any other evidence, the mineralization associated with the granitic intrusives within the headwater basin of Marvel Creek appears to be the only possible source of the placer gold now found along the creek.

GOLD PLACER DEPOSITS.

FORM OF THE CLAIMS.

Marvel Creek is staked for placer mining from its mouth to its headwater basin. The claims are in the form of six association groups, named, in upstream order, the Pioneer, Camp Robber, Yellow Jacket, Hornet, Wild Horse, and Ready Money. Each of these association groups except the Ready Money comprises an area of about 120 acres, or the equivalent of six ordinary 20-acre placer claims. The dimensions of these group claims are approximately 5,200 feet in length and 1,000 feet in width. The Ready Money group contains only the equivalent of three 20-acre claims and is half the length of the other groups. As the valley bottom of Marvel Creek is comparatively narrow, practically all the gravel deposits along the course of the stream are included in a tract 1,000 feet in width. This consideration led the locators to adopt the dimensions stated. Gold was discovered on this creek in August, 1911, and the claims described were staked at that time.

CHARACTER OF THE GRAVELS.

The steep headwater basin of Marvel Creek, on the southern slopes of Marvel Dome, does not appear to have been glaciated. Thus it is in contrast to the upper basin of Robin Creek, on the northern slopes

of the mountain. This contrast is shown not only in the headwater portions of these two streams but in the alluvial deposits along the lower sections of their valleys as well. As a whole the gravels in the Marvel Creek valley are much better assorted than those in the valley of Robin Creek—that is, they show the results of more thorough concentration by normal stream action.

Most of the gravel deposits along Marvel Creek are comparatively shallow. They are distributed along the present flood plain of the stream for a width of 200 to 800 feet and are from 5 to 25 feet in depth. There are also some small, disconnected higher gravel deposits along the borders of the present flood plain that range in depth from 10 to 30 or more feet. These have the position and form of poorly defined sloping bench deposits along the base of the bedrock slopes of the valley. Their surfaces are, for the most part, not very distinct from the lower slopes of the valley, and in some places they merge imperceptibly with the higher portions of the flood plain.

About 4½ miles from the mouth of Marvel Creek, at the point where its two chief headwater branches flow from the steep slopes of Marvel Dome and join, at the upper end of the Ready Money claim, the alluvial deposits are deeper than on the claims below the Ready Money. On this claim a shaft 60 feet deep failed to reach bedrock. The material excavated from this shaft contains a considerable proportion of bowlders of moderate size and many large cobbles. The greater thickness of the unconsolidated deposits at this point and their coarseness are due to the fact that the steep headwater branches of the creek are able to deliver large quantities of heavy wash into the head of the main valley from the slopes of Marvel Dome.

Downstream from the Ready Money claim the alluvial deposits become progressively shallower and finer, yet heavy cobble wash and a number of bowlders occur along the valley for several miles. A peculiarity of the bowlders along the middle section of the creek is that the greater number of them appear to rest on or near the top of the finer gravels, instead of on bedrock beneath the finer wash. Their position with relation to the finer wash seems to be due, at least in part, to their having been carried along the flood plain during periods of torrential stream flow, as if rolled along the top of finer gravel deposits that had been previously distributed along the bed of the valley during more moderate periods of stream flow.

On the Pioneer claim, where the Marvel Creek valley expands laterally into that of Eagle Creek, the sloping bench deposits are much more extensive than up the valley on the other claims, where such deposits occur only here and there as narrow strips along the sides of the flood plain. On the upper part of the Pioneer claim Marvel Creek meanders against a section of the bench gravels on the left and has truncated its channel a few feet into a point of the bedrock floor upon

which the higher gravels rest. It is on this exposure of bedrock, or "rim rock," as it is termed by the prospectors, that gold was discovered on Marvel Creek. Although this discovery is reported to have consisted of $1.08 worth of fairly coarse gold in six pans of gravel, further prospecting at this locality has failed to show the presence of gold in paying quantities. None of the bench gravels farther up the creek have been demonstrated to contain enough gold to pay for working. All the productive gold-bearing gravels appear to be included in the creek gravels of the present flood plain.

The gravels of the Marvel Creek valley are composed chiefly of the sedimentary country rocks. Pebbles and cobbles of the hardened phases, quartzite and slate, predominate. The gravels include also, however, a considerable quantity of cobbles and bowlders of the granitic intrusive rocks that occur on Marvel Dome, at the head of the creek. In general, the gravels are coarse and not well rounded. They include many flattish and somewhat angular forms that have the appearance of talus blocks, whose edges and corners have been only slightly rounded. These shapes are particularly characteristic of the cobbles and bowlders.

Considerable silt is present in some of the gravels, and along some parts of the valley layers of tough yellow clay occur on or near bedrock. Some of the miners contend that the best concentrations of gold occur on these patches of clay and that very little gold occurs in the fine gravels or shattered bedrock beneath the clay layers. Other miners assert that much of the gold is contained in the shattered bedrock. As the bedrock alternates from hard blocky sandstones or quartzites to shattered shales or slates according to the manner in which the sedimentary country rocks are interbedded, it is natural that the conditions for the concentration of gold on or in bedrock should vary from place to place. Some of the layers of clay appear as if they might be the products of the residual decay of the shale bedrock with which they are intimately associated. Practically all the unconsolidated creek gravels are unfrozen and are therefore difficult to prospect by means of shafts.

The fall of Marvel Creek in the distance of about 5 miles covered by placer claims is about 600 feet. About 400 feet of this descent has a grade of about 3 per cent, and the remaining 200 feet, along the lower half of the creek, has a grade of about 1½ per cent. The volume of water in the creek appears to be ample for ordinary mining operations.

DEVELOPMENTS AND PRODUCTION.

The locators of the placer claims on Marvel Creek have not undertaken to mine the ground themselves but have adopted the leasing system of development. During 1912 practically all the ground

staked along the creek was leased to several persons under the usual agreement that a percentage of all production should be paid to the owners as mining progressed. These leases were not apportioned according to the boundaries of the claims as staked but covered parts of claims or two adjoining claims, according to the desires of the lessees.

The principal operation undertaken in 1912 was on a tract of ground that lay chiefly on the upper part of the Camp Robber claim, but also included the lower part of the Yellow Jacket claim. Here an open cut of about 20,000 square feet was excavated by pick and shovel. The gravels were washed through a line of ordinary small sluice boxes. Shoveling in was commenced about the middle of July and continued to the end of September. Over 500 ounces of gold, or approximately $10,500 worth, was mined from this cut. Thus the ground averaged about 50 cents to the square foot in gold recovered.

The bedrock in this cut is a brown coarse-grained blocky sandstone that appears to form a slight bedrock barrier across the floor of the valley. Considerable gold is reported to be contained in the crevices of this rock. It is stated that much of this gold in the bedrock was not recovered by the operation described, because the blocks could not be easily cleaned or washed through the small sluice boxes employed. No mining has been done in this cut since 1912.

Open-cut pick-and-shovel mining was commenced in 1912 on two adjoining leases farther up Marvel Creek, one of which covered 1,200 feet of the central part of the Hornet claim, and the other the upper 2,100 feet of the Hornet and lower 600 feet of the Wild Horse claim. About $3,500 worth of gold is reported to have been mined from the lease of 1,200 feet on the Hornet claim in 1912. Work on this ground was continued during 1913 and about $1,250 worth of gold was produced. In 1914 an attempt was made to expand operations on this lease by installing a flume 24 inches wide and 1,600 feet long with the purpose of ground-sluicing the gravels and hydraulicking them through the flume in large quantities. For this purpose a ditch was dug along the left slope of the valley that delivered ample water to a penstock about 100 feet above the working pit. Canvas hose was used to deliver the hydraulic water to small nozzles. Poor judgment appears to have been exercised in setting the flume in order to give it sufficient grade to carry the gravels and to bring its upper end to a position on bedrock where it could be effectively used for mining of this kind. As installed in 1914 this flume had several sharp curves along its course, where the gravels clogged in the boxes, and its upper end was set about 4 feet above the bedrock floor of the valley, with the result that the gravels, after being ground-sluiced into the cut, had to be shoveled into the flume for washing.

Much of the gravel washed was conveyed from the cut to the boxes in wheelbarrows. A large amount of freely flowing seepage water was present in the cut and hindered the efficient cleaning of the shattered bedrock. The bedrock in this cut is shattered sandstone and shale, and the overburden consists of these country rocks with some of granite. Bowlders of these rocks weighing as much as 100 pounds, together with many cobbles of the same kind, are abundant in the deposit. The gravels containing gold in paying quantities appear to have what is termed a spotted distribution in the deposits as a whole. The operation of 1914 was unsuccessful. A clean-up on August 14 of about 700 square feet of bedrock, representing the labor of four men for 15 days, yielded only $136 worth of gold. Work that was carried on until the later part of September was not expected to yield more than 10 cents to the square foot of bedrock surface. Probably not more than $1,500 worth of gold was produced from this lease of 1,200 feet of ground on the Hornet claim during 1914. The approximate production of gold from this tract may be summarized as follows: 1912, $3,500; 1913, $1,250; 1914, $1,500; total, $6,250. Those interested in this property plan to reset the flume on bedrock in a proper manner and continue mining operations during 1915 by ground-sluicing and hydraulicking with canvas hose.

No mining was done during 1914 on the tract included in the lease that covers the upper 2,100 feet of the Hornet claim and the lower 600 feet of the Wild Horse claim. In 1912 preliminary work on this ground yielded about 6½ ounces of gold, worth about $120. This work was continued in 1913, when about six men were employed for the season. The mining was carried on by shoveling into a line of ordinary small sluice boxes. An area of about 11,000 square feet of bedrock was worked in this manner. The yield is reported to have been about $2,500 worth of gold and to have barely paid the expenses of operation.

A company was organized in 1912 under the name Marvel Creek Mining Co., and reorganized in 1913 under the name Marvel Creek Mining & Development Co., to mine the gravels along the lower half of Marvel Creek. The company leased for five years the tract covered by the Pioneer, Camp Robber, and Yellow Jacket claims and the lower 850 feet of the Hornet claim. The plan of operation adopted was similar to that attempted on the central section of the Hornet claim—that is, it involved ground-sluicing and hydraulicking through a large flume. In 1913 a ditch nearly 1 mile long was dug along the right slope of the valley to furnish hydraulic water, and a large number of flume boxes, 30 inches wide, were built and partly set in place. In the spring of 1914, the flume was completed, and early in June active mining was begun with a crew of 13 men.

Mining was continued until July 21, but did not progress favorably because the flume did not have sufficient grade to carry the gravel and was not set on bedrock. It was necessary to shovel all the gravel up into the flume and to keep several men working along the boxes to prevent the gravels from clogging in the flume. It is reported that panning tests showed the gravels to contain values from 50 cents to $1 to the square foot of bedrock. The cost of the operation, as undertaken, is stated to have been about 50 cents to the square foot. The gold recovered from a clean-up for the seven weeks of operation amounted to 104 ounces, worth about $1,775. Owing to this poor showing operations were discontinued. The men employed received only one-third of the wages due them for their labor. Two men continued to shovel gravel into this flume during the remainder of the sea on. The total production for the operation is estimated to be about $2,000.

The difficulty with the two large flumes installed on Marvel Creek in 1914 was due primarily to the fact that the flumes were not properly set on bedrock with sufficient grade. It seems doubtful whether the grade of the bedrock floor along the lower half of this creek is sufficient to allow setting such a flume so that it would carry the gravels satisfactorily. It appears that some means is necessary for stacking the tailings delivered at the lower end of the flume. However, a simple conveyer operated by a Pelton wheel or similar water-power device should prove efficient for the purpose of elevating and stacking the gravels to a height of 15 or 20 feet. Farther up the creek, on and above the Hornet claim, a 3 per cent grade may be obtained for setting a bedrock flume, and it is probable that the disposal of tailings would not be so difficult, yet mechanical means for such disposal in the form of a tailings giant or stacker may prove necessary.

The value of the total production of gold from Marvel Creek for the three years in which mining has been done may be summarized as follows: 1912, $14,120; 1913, $3,750; 1914, $3,500; total, $21,370.

FISHER CREEK.

Fisher Creek is a stream about 9 miles in length, of good volume, that discharges into Salmon River from the southwest about 5 miles above the mouth of Eagle Creek. Its chief headwaters drain the eastern slopes of Fisher Dome, a mountain mass about 4,000 feet in altitude. From this mountain the upper half of Fisher Creek flows southeastward; it then makes a right-angle turn to the left, so that the lower half of its course flows northeastward into the Salmon.

The basin of this stream is eroded from the same series of interbedded sandstone and shale country rocks that occupy the valley of

Marvel Creek to the north. In the high mountainous ridge that borders the upper half of the Fisher Creek valley on the northeast a few outcrops of granitic dike rocks cut the sedimentary series. Intrusive rocks of the same kind are reported to occur in more massive form in Fisher Dome, at the source of the creek. Prospectors consider that the conditions of intrusion and mineralization in Fisher Dome are similar to those in Marvel Dome.

The men who discovered gold on Marvel Creek state that they obtained fair prospects of fine gold in the gravel bars at the mouth of Fisher Creek before they found coarse gold on Marvel Creek. After staking Marvel Creek they also located placer claims along the course of Fisher Creek, but no prospecting of consequence was done on the latter stream until the winter of 1913–14. At that time a cabin was built at the bend of the creek, about 4 miles above its mouth, and about half a dozen holes were sunk to bedrock in the vicinity of the cabin. These holes, which ranged in depth from 15 to 30 feet, penetrated frozen deposits of silt and gravel. No prospects of gold were found of sufficient worth to encourage further developments. Apparently the upper part of the creek near Fisher Dome, where the intrusive rocks and associated evidences of mineralization are reported to be more abundantly developed, has not been prospected up to the present time.

CRIPPLE CREEK AND TRIBUTARIES.

Soon after Marvel Creek was discovered extensive locations of placer claims were made on the headwaters of Salmon River, especially on Bell and Cripple creeks, two large streams that enter the river on the right from the southeast. Bell Creek is situated immediately east of Cripple Creek, and its mouth is about a mile below the confluence of that stream with Salmon River. Although the gravels within the valley of Bell Creek have been prospected in a preliminary manner, no developments have been undertaken.

GENERAL FEATURES OF CRIPPLE CREEK.

Cripple Creek is a stream of large volume, about 14 miles in length, that discharges into Salmon River about 4 miles above Fisher Creek, or 8 miles above Eagle Creek. This stream, with its three chief west-side tributaries, named in upstream order Porcupine, Dome, and Loco creeks, drains an extensive headwater basin of Salmon River, bounded on the south by mountains whose summits stand from 4,000 to nearly 5,000 feet above sea level. These mountains appear to have been occupied by extensive glaciers during a former period. The rather gentle slopes of the upper half of the

Cripple Creek basin are mantled by heavy morainal deposits, composed chiefly of large bowlders. The irregular features of deposition characteristic of such deposits are well developed on the broad, gently sloping ridge that separates Dome and Loco creeks, and also on the slopes of the upper valley southeast from Loco Creek. Potholes, containing small ponds of water, occur along the margin of the moraine.

Dome and Loco creeks have intrenched their channels into the mantle of moraine, and in some places along their courses have exposed the bedrock floor upon which the morainal deposits rest. From the amount of intrenchment by these streams it may be roughly estimated that the morainal deposits vary in thickness from 25 to 100 feet or more.

The lower half of the Cripple Creek valley, especially along its west side, is occupied by thick deposits of glacial outwash gravels, which also extend down the valley of Salmon River for fully 20 miles to and beyond Dominion Creek, from which similar gravels were discharged into the valley of the main river, as described on pages 337–339. Since these gravels were deposited Cripple Creek and Salmon River have intrenched their channels through them to the bedrock floor upon which they rest, and at many places the streams have cut into the bedrock to depths of 10 to 30 feet. These bedrock exposures, however, do not appear to represent an actual downcutting below the old bedrock grades so much as the lateral truncation of noses of bedrock slopes or spurs that lie buried beneath the gravels, against which the present streams have been deflected during their intrenchment.

CHARACTER OF BEDROCK.

The country rock of practically all that part of Cripple Creek basin that is not hidden by morainal deposits consists of the hard quartzite and slate phases of the sandstone and shale series that occupies the whole area of the Salmon River valley so far as it was examined. The high mountains at the head of Cripple Creek were not visited, but from the predominance of large bowlders of granitic intrusive rock in the morainal deposits throughout the upper half of the Cripple Creek basin it is surmised that massive bodies of granitic intrusives make up a considerable part of the mountains that adjoin this basin on the south. Prospectors report that a large dikelike body of granitic rock is exposed beneath the morainal deposits on the upper course of Dome Creek, and that the domelike mountain at the source of this creek is made up chiefly of intrusive granitic rock.

On the high mountain ridge east of Cripple Creek, between it and Ball Creek, a wide dikelike body of siliceous intrusive rock cuts the

sedimentary country rocks. It is quite possible that many other dikes of a similar kind are intruded into the sedimentary rocks of this basin.

GOLD PLACER PROSPECTS.

Prospects of placer gold occur along the lower 7 or 8 miles of Cripple Creek, within the area occupied by the thick deposits of outwash gravels, and also along the lower half of Dome Creek, which is intrenched into these deposits. The gold has two modes of occurrence—in the shallow, recently washed gravels along the narrow intrenched flood plains of the present streams, and in the thick outwash gravel deposits that now have the position of benches above the drainage levels. It is evident that the gold in the benches is older than the gold in the recent stream wash, and it is probable that all the gold along the beds of the present streams is derived from the the thick bench deposits by the process of secondary concentration that has accompanied the intrenchment of those deposits down to the bedrock floor of the valley.

The source of the gold in the bench gravels, however, is not so evident. Two assumptions may be made regarding it. One is that the gold now found on the older bedrock floor of the valley, at the base of the bench gravels, was concentrated there before the thick deposits of outwash gravels buried the old valley floor. The other is that the gold was introduced into the bench deposits while they were being laid down. If the latter assumption is correct the gold should be distributed more or less generally through the thick gravel deposits, because they are not well assorted. The small amount of prospecting that has been done in the bench deposits of this valley, chiefly by means of several short tunnels, appears to indicate that the placer gold in the bench deposits is concentrated on or very near the bedrock floor, and that the higher portions of the gravels contain little if any gold. While not conclusive, this scanty evidence might be interpreted to favor the first assumption.

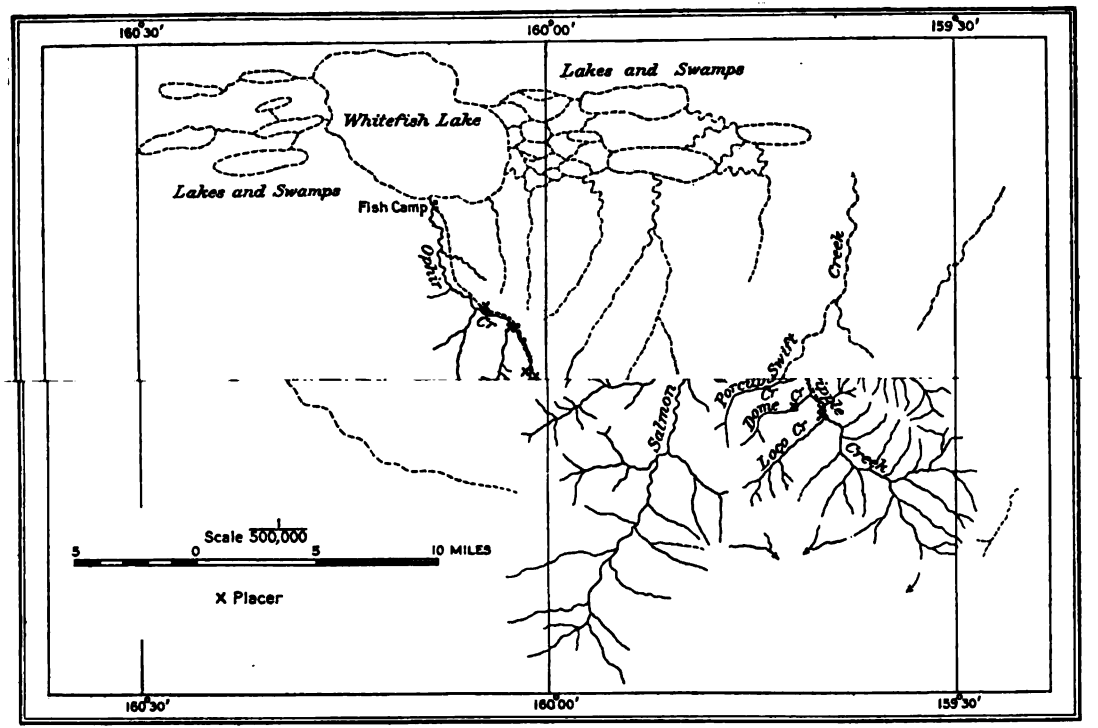
No commercially productive mining has been done on Cripple Creek or its tributaries. The prospecting of the bench gravels by means of tunnels, already mentioned, was done at a point about 2½ miles above the mouth of Cripple Creek, on its left side, where the stream has cut into the bedrock floor to a depth of 10 or 15 feet. It is reported that one tunnel was dug into the gravels for a distance of about 60 feet and that some of the gravels on bedrock showed 2 cents' worth of gold to the pan. The bench gravels at this place are at least 100 feet thick, and it is the opinion of mining men who have examined them that they are too deep to be mined by dredges even if they should be demonstrated to contain commercial quantities of gold.

About 200 yards below the mouth of Loco Creek, on the left bank of the main stream, a narrow strip of bench has been prospected by ground-sluicing and open-cut work. This bench lies along the margin of the morainal deposits that extend between Dome and Loco creeks and appears to consist chiefly of stream-washed morainal material. It contains a number of large morainal bowlders. The water for ground sluicing was conveyed by ditches from small pot-hole ponds on the margin of the moraine a short distance back of the narrow bench and about 50 feet above it. Most of this work was done in 1913. In 1914 one man continued the operation on a small scale. It is not known how much gold was mined, but from the fact that the men who initiated the work abandoned the property it is understood to have been unprofitable.

In the flood plain of Cripple Creek about a mile below the mouth of Loco Creek a bedrock drain was being dug by one man during 1914. A few dollars' worth of fine flaky gold was obtained from this trench, but the presence of gold in commercial quantities had not been demonstrated.

Shallow bar gravels along the present bed of Cripple Creek from 2 to 3 miles above its mouth were washed with a rocker, by one man, during the summer of 1913. This method of mining was much favored during that season by very low water in the streams. Gravel bars that were entirely inaccessible during ordinary stages of stream flow were then within reach. It is reported that some bars, or rather small areas within them, yielded as much as $1 worth of fine gold in an hour of rocking. This, however, was far above the average yield. In 1914 several men attempted to mine one of the most promising of these bars on a larger scale by shoveling into a line of sluice boxes, but the results of this work were practically negligible. The extreme lightness of the gold made it very difficult to save, and a higher stage of the stream prevented digging in as favorable parts of the bar as were available in the summer of 1913

The gold in the shallow gravel bars along the narrow intrenched flood plain of Cripple Creek is probably derived chiefly from the bench gravels by secondary concentration. In eroding into and removing the large quantity of outwash gravels that formerly filled the valley to a considerable depth the main stream appears to have reached and reestablished itself upon the original bedrock floor of the valley, with minor modifications here and there where it has cut laterally into the bedrock floor, as is shown by the low bluff outcrops of bedrock beneath the bench gravels along some sections of the creek. Cripple Creek is a stream of large volume and its grade is sufficient to give it considerable power to transport the gravels along its bedrock floor. It is also subject to violent and sometimes torrential floods each season, and often several



MAP OF TULUKSAK-ANIAK PLACER DISTRICT.

floods occur in one season. Consequently the gravel bars along its channel are not stable but shift more or less from year to year or even from one period of high water to another in the same year. Without doubt a uniform concentration of gold in the present bar gravels is impossible, owing to these fluctuations in the eroding and transporting activities of the stream. Under these conditions the formation of a pay streak of placer gold of any marked continuity in the bar gravels is not to be expected.

PLACERS ON MIDDLE KUSKOKWIM RIVER.

Placer gold has been mined from two tributaries of Kuskokwim River—Crooked Creek and New York Creek—in the middle section of the main valley, where the river has cut across the broad mountain belt of the region from east to west, as described on pages 295, 297.

CROOKED CREEK.

Crooked Creek is a large stream that empties into Kuskokwim River from the north about 18 miles below Georgetown. This settlement, which is now practically abandoned, is half a mile below the mouth of George River, another large north-side tributary to the Kuskokwim, whose basin lies immediately east of that of Crooked Creek. The sources of both Crooked Creek and George River are divided on the north from the headwaters of Bonanza Creek, a large tributary to Iditarod River.

The valley of Crooked Creek extends from north to south for a direct distance of about 35 miles. The area of the valley within which prospects of placer gold occur occupies about 7 miles of its middle length and is about 25 miles south of the rich placers on Otter and Flat creeks, in the Iditarod district.

The country rocks from which the valley of Crooked Creek is eroded comprise the thick sedimentary series of interbedded sandstones and shales that characterize the whole Kuskokwim Mountain belt. In the vicinity of the placer gold locality these sedimentary rocks are cut by considerable bodies of siliceous intrusive rock. It is probable that mineralization from the intrusive rock is the source of the placer gold.

Placer gold was discovered on Crooked Creek in 1909 by prospectors who entered the Kuskokwim Valley from the Iditarod district. The rush of people to the Iditarod in 1910 caused a large overflow of men into the valleys of both Crooked Creek and George River during the later part of that year, especially after gold in paying quantities was found in August on Snow Gulch, a short tributary to Crooked Creek from the east. The excitement that followed this

discovery resulted in widespread staking of ground for placer mining throughout the valleys of Crooked Creek and George River and culminated late in the fall in the establishment of the settlement of Georgetown.

The productive mining on Crooked Creek is practically confined to the lower courses of Quartz, Snow, and Ruby creeks, three gulch tributaries that flow into the main stream from the east. The placer gold occurs in bench gravels that lie along the east side of Crooked Creek and have been intrenched to depths of 15 to 30 feet by the lower courses of the gulch streams, and in the present gravels of these streams, derived by secondary concentration from the bench gravels as a result of the intrenchment.

Quartz Gulch, which empties into Crooked Creek about 12 miles from its source, has proved to be the largest producer of placer gold in the valley up to the present time. In 1910 gold to the value of $1,400 was mined from claim No. 1, at the mouth of this gulch; and in 1912 this claim produced gold to the value of $29,000, of which $23,000 was mined from the stream gravels during the summer and $6,000 from short drifts into the bench gravels during the winter. The open-cut summer mining was done in gravels 6 to 7 feet deep, and the winter drift mining in bench gravels 20 to 25 feet deep. The productive area on Quartz Gulch is rather small, being practically confined to the lower part of claim No. 1, at the mouth of the stream. During 1913 and 1914 two men have mined on this claim and their production of gold has been about $3,000 each year.

On Snow Gulch, which is about half a mile below Quartz Gulch, the first mining in the Crooked Creek valley was done in 1910, at a point about 1,000 feet above its mouth. Here gold to the value of about $2,000 has been produced. In the bench gravels to the right of this locality about $600 worth of gold was mined in 1911 and about $2,300 worth in 1912. Snow Gulch is the only one of the three productive tributaries on which placer gold is reported to be distributed along any considerable distance of the stream. For five claims above its mouth, or a distance of about 1¼ miles, the stream gravels yield appreciable prospects of gold. This distance corresponds approximately to the width of the bench gravels in this part of the Crooked Creek valley, across which the tributaries from the east have intrenched their lower courses on leaving their upper rock-cut gulch sections. It may also be noted that the eastern contact of the igneous intrusive rock which occurs in the gold-bearing area crosses Snow Gulch from the steep mountain spur that separates Snow and Quartz gulches, about 1¼ miles above the mouth of Snow Gulch. This contact with the sedimentary country rocks may mark a zone of gold mineralization from which the placer gold along the stream below this point may be derived.

Ruby Gulch, which is about half a mile below Snow Gulch, is similar to it in all essential features. In 1911 placer gold to the value of about $3,000 was mined from this stream at a point near its mouth.

It is reported that prospects of gold occur along the valley of Crooked Creek from the mouth of Quartz Gulch downstream for a distance of about 7 miles, to the mouth of Crevice Creek, a tributary from the east. Prospect holes sunk in the bench gravels that lie to the left of the main creek throughout this distance have shown values of 10 cents to the pan, and one hole near the mouth of Crevice Creek is reported to have yielded a prospect worth $2.

The production of placer gold from the valley of Crooked Creek may be summarized as follows:

Production of placer gold in Crooked Creek valley.

Year.	Quartz Gulch.	Snow Gulch.	Ruby Gulch.
1910	$1,400	$2,000	.....
1911	.....	2,900	$3,000
1912	29,000	.....	.....
1913	3,000±	.....	.....
1914	3,000±	.....	.....
	36,400±	4,900	3,000

Total, $44,300±.

NEW YORK CREEK.

New York Creek is a small stream that discharges into Kuskokwim River from the north about 3 miles above the small native trading settlement of Hoffmans or Napaimut, which is about 9 miles above Kolmakof. Placer gold was discovered on Murray Gulch, a short right-side tributary to New York Creek, in 1910. More or less prospecting has been done each year since the discovery along the lower three-fourths of a mile of Murray Gulch and in the valley of the main stream near the mouth of this gulch. Although good prospects of coarse gold have been found both in the deep gravels along the bed of Murray Gulch and in strips of bench gravels along the slopes of its valley, no systematic mining operations have yet been undertaken.

A rocky bluff about 500 feet high, on the north bank of Kuskokwim River just below the mouth of New York Creek, affords a good exposure of the sedimentary country rocks of this area, together with some siliceous dikes that are intruded into them. The sedimentary rocks consist of heavy beds of sandstone, from 4 to 6 feet thick, interbedded with dark shales, standing at high angles. The sandstones are much cross fractured or jointed, and the shales are much compressed and crushed. The dikes are intruded diagonally

across the strike of the sediments as irregular bodies that range from 1 foot to 3 feet or more in thickness.

The vein minerals that fill the joint seams in the sandstones and the sheared spaces in the shales consist of an intergrown mixture of calcite and quartz. Lenticular stringers of these minerals, from 1 inch to 3 inches thick, are deposited along the borders of the dikes that cut the sediments. Some highly carbonaceous, almost graphitic gouge has resulted from the crushed shales along the borders of the dikes. Fragments of the shale country rock are included in the dike rock. Zones of reddish iron-stained country rock are common in the vicinity of the dikes.

Both the sedimentary and dike rocks shown in this bluff extend northwestward from the river across the basin of New York Creek. Outcrops of the dike rocks that correspond in trend with those in the river bluff, and are probably extensions of the same bodies, cross the upper part of Murray Gulch 1 mile above its mouth and about three-quarters of a mile back from the outcrops in the bluff. The bedrock source of the placer gold in Murray Gulch is probably closely related to these intrusive rocks, or to zones of contact mineralization along their borders in the sedimentary rocks. All the placer gold that has been found in Murray Gulch appears to be distributed downstream from the dikes that cross the headwater basin of the gulch.

Three 20-acre placer claims cover practically all the alluvial deposits along Murray Gulch that have yielded prospects of gold. The claim at the mouth of the stream is designated Discovery and the claims upstream from it Nos. 1 and 2 above Discovery.

The unconsolidated sediments along the present course of the stream consist chiefly of silt overlying several feet of gravels that rest on bedrock. There is also considerable decayed vegetable matter, or muck, on top of the silt. These deposits are about 35 feet deep at the lower end of Discovery claim and in the valley of the main creek near by. Up the gulch the depth becomes gradually less, being about 15 feet on claim No. 1 above Discovery. The greater part of the sediments along the present stream are frozen, although some of the gravels beneath the silts carry free seepage water.

Most of the prospecting on Murray Gulch has been done by sinking shafts to bedrock. A small prospecting boiler has been used to thaw the frozen ground with steam. In the spring of 1911 the first shaft was sunk at a point about a quarter of a mile above the mouth of the stream, where the deposits are about 15 feet deep. It is reported that two buckets of gravel from the bottom of this hole contained coarse gold to the value of $30; the largest nugget had a value of $3.65, and the smallest piece a value of 30 cents. However, the gold content of the gravels opened by this shaft was not uniform, and

the showing first obtained appears to be the best that has been found on the creek up to the present time. Other work done in the vicinity of this shaft in 1912 resulted in the production of $300 worth of gold from small drifts whose bedrock area was about 400 square feet, the average yield being about 75 cents to the square foot. Altogether, placer gold to the value of about $1,000 has been produced from the prospect shafts and drifts along Murray Gulch.

In 1914 one man prospected bench gravels that lie along the left slope of Murray Gulch by digging trenches at right angles to the direction of the valley. Stream-washed gravels were uncovered at two levels—a lower one about 15 feet above and 50 feet back from the present flood plain of the creek, and a higher one about 70 feet above and 260 feet back from the creek. These gravels do not show on the surface, but are disclosed by removing from 2 to 4 feet of muck and disintegrated bedrock that form the surface cover of the slope. The gravels of the lower level are reported to contain gold in fair paying quantities. The higher gravels show 75 cents in gold to the square foot of bedrock surface. Coarse gold to the value of $80 was picked up by hand from these gravels as the prospect trench was being dug across them. This gold is rough and does not show appreciable wear by stream washing. In this regard it is in contrast to the placer gold in the bed of the present creek. It is planned to bring water to these bench gravels by a ditch about 4,000 feet in length and to mine them by ground-sluicing.

PLACERS SOUTHWEST OF THE TULUKSAK-ANIAK DISTRICT.

The part of the Kuskokwim region described under this heading was not visited by the writer, but the descriptions presented are based on information furnished by reliable persons who are familiar with the area.

Southwest of the valleys of the Tuluksak and Aniak the northwestern slopes of Kuskokwim Mountains are drained by several rivers of considerable length and volume that discharge into the lower tidal section of Kuskokwim River. These rivers, named in order from northeast to southwest, are the Kiselalik, Kuethluk, Eek, and Kanektok. Their sources are in the highest part of the Kuskokwim Mountain belt, where the prominent summits and groups of peaks have altitudes from 5,000 to 7,000 feet above sea level. There are glaciers on some of the higher slopes of these mountains to-day, and prospectors who have explored this region report that there is strong evidence of former widespread glaciation throughout the mountains. This evidence is chiefly in the form of deposits of morainal bowlders and outwash gravels. The outwash gravels occupy all the larger valleys within the mountains and expansive areas along the borders of the Kuskokwim lowlands where the rivers leave the mountains.

Fine colors of gold may be obtained from the present bar gravels of almost all the larger streams that have intrenched the outwash gravels, but placer gold in commercial quantities appears to be confined to the shallow gravels in the smaller gulch tributaries to the larger streams that have not been affected by glaciation. The best-known example of a rich placer deposit of this character is on Canyon Creek.

CANYON CREEK.

Canyon Creek, a small tributary to a branch of Kuethluk River, is about 110 miles northeast of Bethel by winter sled trail. The mountains in the vicinity are about 5,000 feet in altitude and the mouth of Canyon Creek is estimated to be about 2,000 feet above sea level. It is far removed from timber, and lumber for sluice boxes was hauled to it from a point in the lower valley, 40 miles distant. The supplies for the camp are hauled with reindeer from Bethel for 5 cents a pound.

The narrow gulch drained by Canyon Creek is about 2 miles in length. Seven 20-acre placer claims include practically all the gold-bearing gravels in the gulch. In width the gravel deposits vary from 50 to 300 feet. On claim No. 2 below Discovery, near the mouth of the creek, and on the lower end of claim No. 1 below Discovery, the deposits are more than 14 feet deep, as has been shown by prospecting shafts to this depth, which could not be completed to bedrock on account of flooding by seepage water. The overburden gravels penetrated by these shafts did not contain much gold, but it is reported a drill will be used to prospect the bedrock on this part of the creek. On and above Discovery claim the gravels are shallow, ranging in depth from 1 foot to 4 feet.

Gold was discovered on Canyon Creek in 1913 and mining operations were commenced in 1914. The value of the total yield of gold for this year is reported to be about $14,000. This production was made by eight to eleven men, who mined for the whole or a part of the season. The work was done on the upper end of claim No. 1 below Discovery, the lower end of Discovery claim, the lower end of claim "No. 2 above," and the lower end of claim "No. 3 above." It is reported that the values of gold in the gravels are not uniformly distributed, but that the ground mined in 1914 averaged about 45 cents to the square foot.

The stream has a good grade and an ample flow of water for the shoveling operations that are necessary in mining.

A quartz porphyry dike that cuts the country rocks at the head of Canyon Creek is supposed to be the source of the bedrock mineralization from which the placer gold is derived. The placer gold is chiefly

in the form of small and flat, but plump and heavy, nuggets, of the type called "pumpkin-seed gold" by the miners.

RAINY AND KAPON CREEKS.

Rainy and Kapon creeks are two headwater tributaries of Eek River that are about 6 and 8 miles long, respectively. They lie about 5 miles apart and are situated approximately 12 miles southwest of Canyon Creek.

The country rocks along these streams are reported to be slates and conglomerates, cut by granitic intrusives.

Placer gold was discovered on Rainy Creek about 1911, and prospecting has been carried on for the last three years. Claim No. 2 above Discovery, on Kapon Creek, has been opened to some extent. Two men worked there during the summer of 1914, ground-sluicing through a small flume. The grade of the stream is reported to be from 5 to 7 per cent, but the gravels are rather coarse and their tenor of gold is rather low. The gold is dingy colored and in the form of flat hammered flakes. The concentrates associated with the gold are black magnetic sand, small pebbles of cinnabar, and grains of arsenical iron pyrite.

GOODNEWS DISTRICT.

The Goodnews mining district comprises a moderately mountainous area that extends along the eastern shore of Kuskokwim Bay from the vicinity of Goodnews Bay on the south to the lowlands of Kanektok River on the north. A Moravian mission settlement named Quinhagak, at the mouth of Kanektok River, is the post office and supply post for the district.

The chief part of the mountainous area of this district is drained by Aalalik River, a small stream which discharges into Kuskokwim Bay about 7 miles below Quinhagak.

The mountains of this district are reported to be composed of schists, slates, crystalline limestones, and granitic intrusive rocks. Some of the schists and metamorphosed limestones are garnetiferous.

Prospectors from Nome entered the region about Goodnews Bay during the summer of 1900, and since that year discoveries of placer gold have been reported in various parts of the district from time to time. Prospects of gold appear to be generally distributed on most of the tributaries of Aalalik River, within the mountains, 10 to 20 miles back from the coast, and also on some of the short streams that drain the seaward slopes of the mountains into Goodnews Bay, south of the headwaters of Aalalik River, and into Kuskokwim Bay, to the west. Productive mining has been done upon two streams in

the district up to the present time. These are Butte and Kowkow creeks.

Butte Creek is a small tributary to Faro Creek, a large branch of Aalalik River, about 30 miles southeast from the settlement of Quinhagak. Open-cut pick-and-shovel mining has been done on Butte Creek for about ten years, and it is reported that gold of a value between $50,000 and $60,000 has been produced from three or four claims during this period. In 1914 a scraping plant with a gasoline engine for power was installed on claim No. 1 below Discovery for the purpose of mining the deposits more effectively. The gravels on Butte Creek are about 5 feet in depth. Most of the mining has been done on Discovery claim and claims Nos. 1 and 2 below Discovery. These claims, of about 20 acres each, include nearly all the placer deposits on this creek.

Kowkow Creek is about 5 miles south from Butte Creek. The gravels on this stream are about 6 feet in depth. One man mined on Discovery claim for about half the season of 1914.

The production of gold from Butte and Kowkow creeks in 1914 was about $4,000.

Some hand-drill prospecting was done on Faro and Trail creeks in the summer of 1914 with the object of testing the more extensive gravel deposits on the larger streams of the Aalalik basin for dredging. It is reported that the gravels were found to range from 6 to 12 feet in depth, and that the prospects of gold obtained from a dozen or more holes were far less than those which are obtained on Butte and Kowkow creeks, where the average tenor of the gravels is about 30 cents to the square foot.

BEACH GOLD ON TOGIAK BAY.

It is reported that one man was rocking placer gold from beach sands on Togiak Bay during the summer of 1914. The country rocks near by are said to be schists. No details were learned of this new placer gold locality.

COPPER IN THE RUSSIAN MOUNTAINS.

LOCATION AND TOPOGRAPHIC FEATURES.

The Russian Mountains comprise an isolated group of rugged summits that stand prominently above a rolling tract of the Kuskokwim Mountain belt that lies north of the main river, downstream from Kolmakof. (See Pl. X, p. 270.) The central peaks of this group range in altitude from 4,000 to 4,500 feet above sea level and are 10 to 15 miles northwest from Kolmakof. The rugged area dominated by these peaks has an extent of about 10 miles, both from east

to west and from north to south. The group as a whole is flanked by rolling ridges and sloping spurs of the surrounding highland that stand from 1,000 to 2,000 feet above sea level.

The broad valleys of Kolmakof and Owhat rivers, two considerable tributaries to Kuskokwim River from the north, mark off the Russian Mountains and their highland flanks from the Kuskokwim Mountain belt as a whole. Kolmakof River empties into the main river about 1 mile below and opposite the settlement of Kolmakof and receives all the drainage from the eastern slopes of Russian Mountains. Owhat River enters the Kuskokwim about 20 miles downstream from Kolmakof and receives the drainage from the western slopes of the mountain group. The headwaters of Owhat River encircle the Russian Mountains on the north and drain its slopes on that side. The southern slopes of the mountain group are drained by small creeks that flow directly into Kuskokwim River between Kolmakof and Owhat rivers.

GENERAL GEOLOGY.

The areal geology of the Russian Mountains appears to be directly expressed by the topographic features of the group. The rugged mountain masses of the high central area are composed of intrusive granitic rocks that are chiefly of deep-seated porphyritic character. The highlands that surround the central igneous mass are made up of the sedimentary series of sandstones and shales that form the greater part of the Kuskokwim Mountain belt. The Russian Mountains appear to be made up of a batholithic igneous mass intruded into the sediments.

MINERALIZATION.

A deposit of gold-bearing antimony is reported to occur at or near the contact of the central igneous mass with the surrounding sedimentary rocks on the upper part of Mission Creek, in the southwestern part of the Russian Mountains. Prospects of placer gold are reported to be present in the gravels of Mission Creek below this locality, and the placer gold is presumed to be derived from the zone of stibnite mineralization. It is not improbable that there may be other occurrences of mineralization of the contact type about the borders of the intrusive igneous rocks.

COPPER LODE.

A lode deposit of metallic sulphides occurs in the central part of the Russian Mountains several miles within the outer limits of the massive intrusive rocks, in the upper basin of Cobalt Creek, a stream that flows for 8 miles northward into upper Owhat River.

Four claims, collectively known as the February group, are staked along a vein deposit of the fissure type that may be traced by its surface croppings for a distance of about 4,000 feet. The general strike of the vein is N. 20° W. and its dip is 85° SW. The width of the vein has been determined at only one point, near the north end of its outcrop, where a shaft has been sunk upon it to a depth of about 40 feet. In this shaft the fissure walls are well defined. At the surface these walls are about 5 feet apart, but at a depth of 25 feet they are about 30 inches apart, and this width between the walls continues to the depth of 40 feet without appreciable change.

The gangue of the vein is quartz. The metallic sulphides with the quartz are a mixture of chalcopyrite, arsenopyrite, and pyrite. The ore carries copper, gold, and silver, but the writer did no sampling. At the time of visit the greater part of the shaft was filled with water, so the minerals could not be examined in place. It is reported that the arsenopyrite appears to be more abundant near the surface and the chalcopyrite at the bottom of the shaft.

The wall rocks are considerably leached near the surface, but that of the footwall appears to be more porphyritic than that of the hanging wall. Along both walls are thin seams of a fine-grained talcose gouge, considerably stained with malachite. Malachite stains together with dark iron-rust stains occur on much of the quartz that marks the surface outcrop of the vein.

This prospect was first brought to the attention of white men about 15 years ago by Indians, who discovered it while hunting. It was staked at that time but abandoned soon afterward. The present claims were staked in 1913, and a log cabin was built near by early in the winter of that year. A shaft was sunk to the depth of about 25 feet early in 1914 and was continued to a depth of 40 feet or more during the winter of 1914–15.

The best route for hauling supplies to the property is by way of a winter sled trail from Kolmakof, 18 miles long. This trail follows the valley of Suter Creek, a tributary to Kolmakof River, and swings around the northeast end of the Russian Mountains into lower Cobalt Creek. The nearest timber is on the upper part of Suter Creek, about 5 miles from the prospect. The divide between Suter and Cobalt creeks is estimated to be not more than 1,000 feet above Kuskokwim River at Kolmakof. It would not be difficult to construct a wagon or tram road to the property by this route.

IRON-ORE DEPOSITS NEAR NOME.

By HENRY M. EAKIN.

INTRODUCTION.

Considerable local interest has long attached to deposits of iron ore in an area that centers about 25 miles northwest of Nome. A day was spent at this locality by the writer in July, 1914, and some of the more important properties were hastily examined. No previous study of the deposits had been made by the Survey.

GEOGRAPHY.

Five groups of claims are held in the iron-bearing district. Three of these—the Mogul, Monarch, and Galena groups—are on the height of land between Sinuk River and Washington Creek, a south tributary of the Sinuk. The American group, comprising four claims, is west of Sinuk River below American Creek, and the Cub Bear group, also of four claims, crosses the divide between Washington Creek and Cripple River. Heavily iron-stained blossom occurs at half a dozen other places in the same general area.

The Monarch group was reached easily in a day's travel on horseback from Nome, the route followed being along the beach to Penny River, up this stream to Willow Creek, and thence northward across the heads of Arctic Creek, Cripple River, and Washington Creek. There is no definite trail to follow beyond Arctic Creek, but the country is open and easily traversed.

The immediate vicinity of the principal properties has a sharp topographic relief of 800 to 1,000 feet. The valleys are fairly broad, but the interstream ridges are generally steep sided and more or less broken along their summits. Timber is absent, and the rocks are well exposed on all the higher features.

Those interested in the iron ores have proposed the construction of a railroad from the vicinity of the properties to the coast along the Sinuk River valley. The route is apparently practicable and would give a down grade all the way to the coast, a distance of about 14 miles.

GEOLOGY.

The bedrock of the iron-bearing area consists chiefly of the several formations of the Nome group,[1] including the Port Clarence limestone and other limestones, schists, and slates of early Paleozoic age. The iron-ore deposits are chiefly in limestone areas that were mapped by Collier[2] with the undifferentiated members of the group. There is a small area of Tertiary sedimentary rocks, including thin coal seams, on Coal Creek, a west tributary of Sinuk River about 3 miles west of the Monarch group of claims.

The valleys are floored with alluvium, part of which is of glacial origin. Gravel beds and erratic bowlders are widely distributed at elevations up to 1,000 feet above sea level. The aggregate area covered by high-level gravel beds, however, is not large.

The iron-ore deposits consist of limonite veins and stockworks and their residual products. Hematite, galena, pyrolusite, and small quantities of gold also occur as accessories in some of the lodes. The examination was too brief to permit detailed studies, but the general impression gained is that there had been strong mineralization at certain localities, and that the mineralizing agencies had affected a considerable area. The following brief notes will serve to indicate the character of the ores at several localities.

CLAIMS.

MONARCH GROUP.

The Monarch group, including 14 claims, or about 300 acres, lies on the limestone ridge that trends eastward between Sinuk River and Washington Creek. It covers the ridge top for about 3,000 feet and extends laterally for over a mile. Within this property the ridge crest is broken by two gaps at an elevation of about 1,000 feet above sea level, in which are the chief deposits of iron ore. Elsewhere the limestone is more or less iron-stained and may contain small ore veinlets, but the average iron content of the limestone mass may be too low to permit its being classed as ore.

The east gap is mantled by a heavy residual deposit of limonite and hematite, derived from the weathering of unusually abundant ore veins that cut the underlying limestones. The residual ores have also slumped down into the head of the gulch that leads northward from the gap, where they occur in considerable amounts. The veins in bedrock beneath the gap are apparently numerous, and range in width from a few inches to about 30 feet. They are approximately

[1] Collier, A. J., and others, The gold placers of parts of Seward Peninsula, Alaska: U. S. Geol. Survey Bull. 328, 1908.
[2] Idem, pl. 10.

vertical, but their persistence, either vertically or horizontally, is not determinable from the exposures.

In the west gap there is no important accumulation of residual ore. The underlying limestone is cut, however, by a wide stockwork of limonite and pyrolusite veinlets. No heavy veins were seen at this locality.

The residual deposits of the east gap have been developed over an area approximately 600 by 800 feet, in open cuts that range from a few yards to several hundred feet in length. A shallow shaft and a short drift have been driven into the deposit in the head of the northerly gulch, 50 feet below the gap level. An open cut at the south margin of the gap has uncovered a mass of undisturbed limonite, apparently a vein 30 feet in width, cutting the limestone country rock.

In the west gap several short open cuts have been made in loosened bedrock material which contains numerous veinlets of limonite and pyrolusite. Elsewhere on the claims the iron-stained limestone detritus has been thrown out of open cuts without revealing any high-grade ores.

The residual ore of the east gap has a loose granular texture and a high iron content, and is unusually free from injurious impurities. Two samples taken by the writer, one from an open cut at the east margin of the deposit and the other a composite sample from a line of open cuts 400 feet long across its center, were found to contain 53 and 55 per cent of metallic iron, respectively. The complete analysis of the composite sample, which is probably fairly representative of the whole deposit, is as follows:

Analysis of composite sample of iron ore from Monarch group of claims.

[Analyst, R. C. Wells, United States Geological Survey.]

SiO_2	5.53	TiO_2	None.
Al_2O_3	1.34	P_2O_5	.13
Fe_2O_3	78.30	S	Trace.
MgO	.10	MnO	1.37
CaO	1.97	BaO	Trace.
H_2O	10.40		
CO_2	1.10		100.24

The iron, manganese, phosphorus, and sulphur contents of the ore, calculated from this analysis, are as follows: Fe, 54.81; Mn, 1.06; P, 0.057; S, trace.

No samples were obtained from the veins from which this residual material has been derived. The character of the ores in the undisturbed veins was therefore not determined.

Only qualitative analyses of samples taken from the west gap were made. They contain limonite and pyrolusite in about equal amount.

The veinlets appear to comprise only a small part of the general mass of the stockwork, so that the iron and manganese content of minable material is probably not high.

The development work done so far on the Monarch property has failed to furnish an adequate basis for estimating the quantity of ore available in either the residual deposits or the underlying veins. The size and extent of the veins for the most part can only be conjectured. The area of the residual deposits is fairly well outlined, but their depths have not been generally demonstrated. However, it seems certain that the residual high-grade ores aggregate at least several hundred thousand tons. Apparently they cover an area 600 by 800 feet to a depth of several feet. In places shafts 12 feet deep are said to have been sunk in ore. Although ore occurs in the head of the northerly gulch 50 feet or more below the level of the east gap, it is unsafe to assume that the divide is underlain by ore to this depth, for this ore is apparently not in place, but has slumped down into the head of the gulch from the gap above. Obviously additional prospecting will be required to determine accurately the reserves of high-grade residual ores and to demonstrate the availability of the undisturbed vein ores. The stockwork of the west gap will also require careful investigation to determine its value. The relatively high manganese content of the veinlets and the reported association of gold with the manganese strengthens the possibility that this deposit may prove of commercial value.

The limestones on the property away from the gaps contain from 5 to 40 per cent of iron. The average content is probably nearer the lower figure, and if this proves true it seems doubtful that much of this material can be considered as commercial ore.

MOGUL GROUP.

The Mogul property consists of four claims situated on the Sinuk River and Washington Creek divide about 1½ miles east of the Monarch property. No development work has been done here, the locations being made on the strength of a few acres of the blossom of ore veins that cut the limestones locally. Evidence of the veins is found in heavily iron-stained limestone detritus that has a scant admixture of limonite nodules and vein fragments. There is little evidence as to the size and extent of the veins or the possibilities of commercial development.

GALENA GROUP.

The Galena group, which was not visited by the writer, consists of nine claims situated 2 miles southwest of the Monarch property. Several open cuts, shafts, and short drifts are reported to have been

made on the property, uncovering a number of veins and small stockworks bearing limonite and galena. No large bodies of ore are reported to have been developed up to midsummer, 1914, but sufficient encouragement had been given by the findings to stimulate further development work, which was then in progress.

AMERICAN GROUP.

The American group includes four claims situated at the base of a limestone ridge west of Sinuk River, below American Creek, 2 miles northwest of the Monarch property. The locations are said to cover an "iron-ore bed" over 50 acres in extent. The only development work done consists of a few pits 6 to 8 feet deep, and no analyses have been made of the ore. The locality was not visited by the writer.

CUB BEAR GROUP.

The Cub Bear group includes four claims located end to end along the croppings of iron-ore veins cutting across the limestone ridge between Washington Creek and Cripple River. The blossom of the veins, where it shows through the vegetation at intervals, consists of the usual iron-stained limestone detritus mixed with limonite nodules and vein fragments. A few shallow pits have been dug, revealing limonite-hematite veins as much as several feet in width. Large blocks of ore taken from some of the pits exhibit botryoidal and mammillary forms and fibrous texture and are essentially pure limonite with possibly a very little accessory hematite. No estimate of the amount of ore in the deposit or of its availability for mining is possible at the present stage of development.

PLACER MINING IN SEWARD PENINSULA.

By HENRY M. EAKIN.

GENERAL PROGRESS.

The chief progress made in the placer-mining industry in Seward Peninsula in 1914 consisted in further consolidation of properties for new dredging ventures, the financing of additional mining concerns, the construction of new dredges, and a general improvement in the success of dredging operations. Forty dredges (including one tin dredge), with an aggregate daily capacity of 42,000 cubic yards, operated for all or a part of the open season in 1914, against 34 dredges, with an aggregate daily capacity of 33,400 cubic yards, in 1913. Four new dredges were completed, and four others that were reported as under construction in 1913 were in the same condition in 1914. At least three additional dredges were contemplated for construction before the season of 1915.

The dredging season of 1914 was unusually short. On account of winter frost, snowbanks, and valley ice but few dredges commenced operations before July 1, and many were tied up until July 15 or 20. The four new dredges completed during the summer began operating at still later dates. The operations were cut short in the fall by an unusually early freeze-up.

Other forms of placer mining were carried on with varying success in all the productive districts. The water supply for hydraulic and ground-sluicing operations, although much better than in 1913, was only fair, and some of the larger plants were unable to work at full capacity much of the season. A little drift mining was done both in summer and in winter, but in general these operations were of relatively minor importance.

An important element of progress in the mining industry in Seward Peninsula is the development of economies that render gravels of lower and lower grades available for exploitation. Among these may be mentioned the removal of hazard in dredging operations by systematic prospecting, the reduction of overhead costs by the formation of larger companies that operate a number of dredges under the same superintendency, reduction of fuel expenses by use of

internal-combustion engines burning crude oil, a more efficient use of steam in thawing frozen ground, and a closer attention to economy in the commissariat. Attention is also being given to the saving of gold from the black sands that are produced in large amounts in the vicinity of Nome. A plant was installed at Nome for this purpose during the summer, and presumably it began operating before the end of the season. There is promise of a further economy in thawing the frozen coastal-plain deposits near Nome by systematic application and withdrawal of surface waters. Fortuitous occurrences incident to the artificial drainage of dredging ground indicate the possibility of developing such a method of thawing, which is a crucial necessity to the economic exploitation of the enormous low-grade reserves of the Nome coastal plain.

In all about 1,200 men were employed in mining on Seward Peninsula in 1914 for an average season of 100 days. About 450 of these men were employed on dredge crews and in dredge construction. The total production of the placers has an estimated value of $2,700,000.

OPERATIONS BY DISTRICTS.

NOME DISTRICT.

DREDGING.

The dredging situation in the Nome district showed marked improvement in 1914 over the preceding year. In 1913 there were thirteen dredges in the district, of which seven were operating, three were idle, and three were under construction. In 1914 eleven dredges operated, and the same three were still incomplete. Two new dredges were installed during the year, and the old Peluk Creek dredge was taken to Anikovik River, in the Port Clarence district.

The two new dredges were built on Bangor and Arctic creeks. The Bangor dredge has a close-connected line of 3½ cubic-foot buckets, develops 150 horsepower with an internal-combustion engine using crude oil as fuel, and has an estimated daily capacity of 2,000 cubic yards. The fuel consumption is estimated at 6 barrels of crude oil a day. It was planned to complete its construction and begin operating by September 1.

The Arctic Creek dredge is of the flume type, with a 2½ cubic-foot open-connected bucket line. It has 60-horsepower distillate engines, using 100 gallons of fuel a day. Its capacity is estimated at 1,000 cubic yards daily. The dredge was completed and operation commenced July 20.

There is considerable divergence of opinion as to the most economical size and type of dredge for use in the district. The capacity of buckets in the active dredges ranges from 1¾ to 10 cubic feet.

The estimated costs per yard of gravel do not differ materially with the size of dredge employed, being, as a rule, 10 to 15 cents in thawed ground and 20 to 30 cents where steam thawing is required. These figures do not include royalty, amortization, or other overhead charges. Some significance may attach, however, to the fact that the more recently built dredges now operating are of the smaller type and the dredges that have been under construction for several years and are still incomplete are of the larger type.

The future of the dredging industry in the Nome district hinges strongly on the possible development of cheap methods of thawing the frozen coastal-plain deposits. These deposits comprise the greater part of the known reserves of the district. The thawed gravels along the courses of streams have a much smaller areal extent and their exploitation is a comparatively simple matter. At present the frozen deposits are thawed in advance of dredging operations by means of steam points driven from the surface to the required depth. Although this method is fairly economical in relatively shallow and rich deposits, its present cost is prohibitive for the deeper and leaner placers that constitute the larger reserves of the coastal plain.

A possible method of thawing the coastal-plain deposits more cheaply by means of ditch water is suggested by the results of an artificial drainage project in the vicinity of Nome. A drainage ditch was dug across the tundra at a short distance from one of the natural watercourses and parallel with it. In places the excavation penetrated through the muck and into the surface of the underlying gravels. After a time it was noted that considerable water was lost from the ditch by seepage, presumably through the gravels toward the natural watercourse, along which there was a zone of thawed ground. Later the thawed strip of gravel along the stream was dredged, and it was found that the area between the ditch and the stream was also thawed and available for dredging. Apparently the ditch water seeping through the gravels eliminated the ground frost to progressively greater depths, until the circulation affected the whole thickness of the gravels down to bedrock. The depth of thawing the first summer exceeded the depth of winter frost of the following season, so that the second summer's thawing was added to that of the first, and so on to bedrock. It is estimated that the surface of ground frost was lowered about 20 feet a year.

This occurrence accords with the laws of ground-water circulation as developed by Slichter[1] and applied by Van Hise.[2] The waters

[1] Slichter, C. S., Theoretical investigation of the motion of ground waters: U. S. Geol. Survey Nineteenth Ann. Rept., pt. 2, pp. 297–384, 1899.

[2] Van Hise, C. R., A treatise on metamorphism: U. S. Geol. Survey Mon. 47, pp. 571–576, 1904.

do not move in straight lines between the point of entrance into the gravels and the point of their withdrawal, but tend to follow a number of divergent paths from the former and of convergent paths near the latter. The coastal-plain gravels, where thawed, are fairly homogeneous and offer a nearly uniform degree of permeability to ground waters. The ideal circulation would be modified at the inception of the process by the high level of the surface of ground frost. As this surface was lowered by the influence of the relatively warm ditch waters the circulation would take on more and more the ideal form. The rate of circulation of ground water is affected by the difference in elevation between the points of entrance and exit, being more rapid under a higher head. The depth of gravels affected would depend somewhat on the horizontal distance between these points.

The general principles of a possible method of thawing by systematic application of ditch waters and withdrawal of ground waters seem clear. The details of such projects will have to do with topographic conditions, the muck overburden of the gravels, and the degree of homogeneity of the deposits. Although no insurmountable obstacles to the development of this method are apparent, it will probably require a great deal of careful experimental investigation to develop an efficient practical application of it.

OTHER FORMS OF PLACER MINING.

Extensive hydraulic-mining operations were carried on by the Pioneer Mining Co. on and near Center Creek. Four hydraulic lifts on different claims were used intermittently, as water from the Miocene and Pioneer ditches was available. An average of about 125 men were employed. A considerable shortage of water prevented continuous operation of all the plants at full capacity, but a large production was made.

Drift mining in the vicinity of Nome has fallen off greatly in relative importance each year since 1907, but there is still a considerable production from this source. The present operations are confined to placers of moderate gold tenor that are available only for the most economical methods. Expenses are reduced by a more economical use of steam for thawing, pressure being turned on the points for three hours instead of six as formerly, and a longer period of sweating allowed. The expense of the commissariat is also reduced, so that the daily cost of board per man is in some places as low as 90 cents instead of the $2 or $3 formerly allowed. These practices have permitted the reopening of several mines that previously had been abandoned on account of their low gold tenor.

Other mining operations reported in the vicinity of Nome during 1914 are as follows: Anvil Creek, one open-cut plant; Dexter Creek,

deep mining during winter; Nugget Gulch, open-cut mine; Daisy and Nicola gulches, open cut; Glacier Creek, open cut; Last Chance and Jess creeks, one hydraulic plant each; Cripple River basin, one small hydraulic plant on Oregon Creek and one open-cut mine on Willow Creek; Osborn Creek, one hydraulic mine; Boulder Creek, one open-cut mine with hydraulic lift; Buster Creek, one open-cut mine. Some drift mining was also reported on the third beach line.

An interesting though relatively unimportant phase of placer mining at Nome was the renewal of beach mining. The severe storm of 1913 was attended by a notable attack on the seaward scarp of the coastal plain, which in places was eroded back 60 to 100 feet. This resulted in the formation of new concentrations along the beach above the usual strand line, and during the summer of 1914 from 50 to 100 men were engaged in working them with rockers, surf washers, and short sluice boxes along the beach from Nome to Penny River. The concentrations were not very rich, and only ordinary wages were made.

SOLOMON DISTRICT.

Eight of the nine dredges that operated in the Solomon district in 1913 continued work in 1914, and one new dredge, built early in the summer, began work in August. The only dredge reported idle was that of the Nome, Montana & New Mexico Mining Co. on Goose Creek, which suspended operations pending additional prospecting. It is reported that at least four of the active dredges exhausted their available ground during the summer.

The new dredge was built for C. E. Kimball on Adams Creek. It has an open-connected line of 2½ cubic-foot buckets, develops 60 horsepower with distillate engines, uses 100 gallons of fuel a day, and has an estimated daily capacity of 1,000 cubic yards.

An innovation was introduced among the various types of power plants used on Seward Peninsula by W. H. Esterbrook, who has taken an option lease on the ground and equipment of the Seward Dredging Co. on Solomon River. The new plant is equipped with a 4-cylinder 4-cycle Diesel engine of 200 horsepower and a corresponding electric generator. It began operating the later part of July, and is said to have given very satisfactory results for the rest of the season. The fuel consumption is reported as 6 to 10 barrels of crude oil a day, compared with 42 to 50 barrels required by the steam plant that was replaced.

No mining other than dredging was in progress in the Solomon district. Two small outfits are reported to have prospected for elevated beach deposits in the vicinity of Jerome Creek during the summer and to have found such deposits at two levels, 130 and 150 feet above sea. The value of the discoveries is not disclosed.

CASADEPAGA DISTRICT.

Four dredges operated in the Casadepaga district, as in 1913, with the exception that the small dredge of the Oro Dredging Co. was moved from Goose Creek to Elkhorn Creek, a tributary of Niukluk River below the Casadepaga. The other three dredges worked on Casadepaga River, Willow Creek, and Goose Creek. No other mining was done in the district.

COUNCIL DISTRICT.

Six dredges continued operation in the Council district, as in 1913, with the exception that one of the Flume Dredging Co.'s dredges was moved from Ophir Creek to Crooked Creek. Of the other dredges, two worked on Ophir Creek and one each on Melsing, Mystery, and Warm creeks.

Hydraulic mining was carried on by the Wild Goose Mining Co. on Dutch Creek and by Stick & Co. on Albion Creek. A steam-scraper plant was operated on Melsing Creek.

It is estimated that fifteen different plants, employing about 120 men, were operated in the district, distributed as follows: Ophir Creek and tributaries, five; Crooked Creek, three; Melsing Creek, three; Warm Creek, three; Elkhorn Creek, one. There was no winter work in the district. The value of the gold produced in the district in 1914 is estimated to be $525,000.

KOYUK RIVER DISTRICT.

Renewed mining activity is reported on Sweepstakes Creek, where ten men are working four separate claims. Recent discoveries are said to have disclosed valuable placer ground in this section, and an increased activity is expected in 1915.

On Kenwood Creek, a south tributary of Koyuk River 20 miles above its mouth, a single outfit was working in a small way.

FAIRHAVEN DISTRICT.

About 75 men are reported to have engaged in mining on Candle Creek and tributaries in 1914. The Candle Creek Mining Co.'s dredge had a successful season. On claim No. 20, above Discovery, a steam-scraper plant was operated. Twelve smaller outfits were engaged in ground-sluicing and drifting on the benches of the Candle Creek valley, and one plant drifted on Jump Creek.

Four plants operated on Bear Creek during 1914, and one on Sheridan Creek, a tributary. About 20 men were employed. One plant operating on Discovery claim had a hydraulic equipment, including a Ruble elevator, and used water from the Bear Creek ditch

under a 240-foot head. The other outfits used manual methods in open-cut work.

The Kugruk dredge operated successfully for a part of the open season. Two drilling outfits were engaged in testing ground for further dredging operations, and one drift mine was worked by a small force.

The two dredges on Inmachuk River were late in starting, owing to an unusual accumulation of winter ice, but operated successfully the later part of the season. The other mining activities in the Inmachuk region have not been reported.

KOUGAROK DISTRICT.

The Alaska-Kougarok Dredging Co. operated its 2¾-cubic-foot dredge successfully on Kougarok River at the mouth of Henry Creek during the open season. The Behring Dredging Co. has drilled extensively on its holdings and has a 2½-cubic-foot close-connected bucket-line dredge landed at the head of navigation ready for transportation to Kougarok River below the mouth of Taylor Creek, where it is to be installed for operation during the summer of 1915. Plans have also been made for installing a dredge on Iron Creek.

The North Star ditch, which takes water from Taylor Creek, was used in hydraulic mining on claim No. 15, above Discovery, Kougarok River. A small hydraulic plant was installed on Macklin Creek. The other activities include five sluicing plants on Kougarok River, four on Dahl, two on Coffee, seven on Iron, two on Willow, one on Benson, two on Macklin, and two on Garfield.

The winter work in this district included two deep-mining plants on Kougarok River, one on Willow Creek, and one on Iron Creek, employing in all seven men and producing about $12,000 worth of gold. Thirty-four plants were operated in summer, employing about 130 men. The value of the gold produced in the district in 1914 was about $150,000.

PORT CLARENCE DISTRICT.

Six dredges operated in the Port Clarence district in 1914, but only three of them for much of the season. The open season was unusually short, extending only from the middle of July to early in October.

Three of the dredges operated for gold on Windy, Dick, and Sunset creeks. The York Dredging Co.'s dredge continued working for tin alone on lower Buck Creek.[1]

The American Gold Dredging Co. put two dredges on Anikovik River and operated for tin and gold together. One of these dredges

[1] Eakin, H. M., Tin mining in Alaska: U. S. Geol. Survey Bull. 622, pp. 89–92, 1915.

was formerly on Peluk Creek near Nome and the other was new. The Peluk dredge was towed along the shore of Bering Sea to the mouth of the Anikovik, where it dug its own way across the bar into the river. It was then laid up in order to remodel the digging ladder and bucket line. The new dredge was installed on the river about a quarter of a mile from its mouth. It has buckets holding 2 cubic feet in an open-connected line, develops 80 horsepower by distillate engines, and has an estimated daily capacity of 800 cubic yards.

INDEX.

A.

Page.

Acknowledgments to those aiding 5-6, 58, 83, 248, 293
Alaska, southeastern, field work in 11
mining in 40
southwestern, mining in 47
Alaska-Ebner Gold Mining Co., developments by 100-101
Alaska Free Gold Mining Co., work of 48
Alaska Gastineau Gold Mining Co., operations by 98-99
Alaska Hydroelectric Co., power development by 40
Alaska-Juneau Gold Mining Co., development by 100
Alaska Treasure Consolidated Mines, development in 97-98
Alaska Venture Syndicate, development work by 42
Alaska-Washington Gold Mining Co., development work by 139
Alaskan claim, description of 169
Albert Creek, gold placers on 128
Alder Gulch, gold on 222
Alice mine, description of 175-176
American Creek, placer mining on 245
American (iron) group, description of 365
Aniak River, basin of, gold in 301
description of 308
See also Tuluksak-Aniak district.
Anikovik River, dredging on 372-373
tin placers on 91-92
Antimony, occurrence of 258, 266-267
Appropriation, allotment of 8-9
Avery River, development work on 135
Azurite, occurrence of 107-108, 110, 112

B.

Baker Creek basin, placer mining in 242
Bald Mountain group, description of 179-180
Bear Creek, description of 309-310
geology of 310-311, 313-321
glaciation on 319-321
effect on placers 320-321
gold on 311-312, 315, 316-318
gravels of 310-311, 314-319
Beaver Creek, basin of, lignite of 228
gold lodes on 224
Bell Creek, gold of 347
Benito Creek, gold lode on 115
Bering River coal field, development in 43
opening of 104
test of coal from 25-27
Berners Bay district, mining in 41
Bethel, supplies from 302-303
Big Eldorado Creek, gold of 204-205, 220-221

Page.

Big Four claim, description of 164-165
Big Harbor mine, development work in 41-42
Birch Creek district, mining in 60-61
Black & Hogan claims, development of 139
Black Gulch, cinnabar at 286
Bluebird group, description of 182
Bogus Creek, gold on 331-332
Bonanza Creek (Chisana drainage), gold placers on 208-216, 224-225
Bonanza Creek (Mulchatna basin), gold of. 263, 311
Bondholder claim, work on 238
Bornite, occurrence of, in the Kotsina-Kuskulana district 107-108, 109, 110, 111, 112, 113, 114, 115
Brooks, A. H., administrative report of 7-14
on Alaskan mining industry in 1914 15-68
on Valdez mineral resources 152
preface by 5-6
Bryan Creek, gold on 223
Buck Creek, tin placers on 89-91
Budd Mining Co., placer claims of 187
Bunker Hill claim, description of 181
Butte Creek, gold of 358

C.

Cache Creek, placer mining on 244
Cairnes, D. D., on Chisana-White River district 205-207
California Creek, gold on 331
Cameron-Johnson Gold Mining Co., claims of 172-174
Camp Robber claim, work on 344, 345
Candle Creek, gold on 261
Canyon Creek, gold of 356-357
Capps, S. R., on mineral resources of Chisana-White River district 189-228
Carboniferous rocks, occurrence and character of 199
Casadepaga district, placer mining in 371
Cassiterite, occurrence of 85, 86, 87, 89-94
Chalcocite, occurrence of 107-108, 109, 110, 111, 112, 114, 115
Chalcopyrite, occurrence of 107-108, 109, 111, 112, 113, 114, 115, 132
Chandalar district, mining in 64
Chapin, Theodore, on auriferous gravels of Nelchina-Susitna region, paper on 118-130
Chathenda Creek, gold on 221, 222, 224, 225
lignite on 228
Chavolda Creek, gold on 223
Chichagof mine, development at 43
Chisana district:
geologic map of 202
gold tenor of gravels of 75-76
mining operations in 60

Page.

Chisana-White River district, copper of.... 226–227
economic conditions in..... 203
geography of..... 191–198
geology of..... 198–202
glacial deposits of..... 201–202
glaciation in..... 192–193
gold in..... 202–225
description of..... 208–223
origin of..... 203–208, 226
production of..... 224
lignite in..... 227–228
location of..... 189
map showing..... 189
map of, showing mines and prospects.... 202
mineral resources of, report on..... 189–228
nomenclature in..... 191
Chistochina district, mining operations in... 44–45
Chitina district, mining in..... 45, 104–105
Chitistone limestone, occurrence and character of..... 106–107
Chititu Creek, gold on..... 104
mining on..... 116–117
Chokosna River, mining on..... 114
Cinnabar. *See* Mercury.
Circle district, gold tenor of gravels of..... 76
mining in..... 60–62
Clear Creek, mining on..... 113
Cleary Creek, gold on..... 230–232, 237
prospecting on..... 238
Cliff mine, description of..... 170–172
Coal, consumption of, from 1899 to 1914..... 24–25
leasing law for, and regulations thereunder..... 31–38
production of, from 1888 to 1914..... 17, 21, 24
steaming tests of..... 25–30
Coal Creek, lignite on..... 227–228
Columbia Glacier, mines near..... 183–186
Consolidated claim, development work on... 135
Cook Inlet, gold tenor of gravels of..... 76
Copper, occurrence of, in Chisana-White River district..... 226–227
occurrence of, in Iliamna-Lake Clark region..... 257–258, 266
on Prince William Sound..... 131–134
ores of, genesis of..... 108
shipment of..... 105
production of, from 1901 to 1914..... 17, 18
Copper, native, occurrence of..... 107–108, 109, 110, 111
Copper Center, location of..... 122
Copper Creek, gold on..... 116
mining on..... 111–112
Copper mining, progress of..... 16, 21, 22
Copper River basin, field work in 11–12
gold tenor of gravels of..... 76
mineral resources of, map showing..... 104
mining in..... 44–45
Copper River & Northwestern Railway, distributing points on..... 103–104
Cottonwood Creek, prospecting on..... 129
Council district, placer mining in..... 371
Cretaceous coals, occurrence and character of. 268–269
Cripple Creek basin, description of..... 347–348
geology of..... 348–349
gold of..... 349–351
mining in..... 62

Page.

Crites & Feldman claims, work on..... 236–237
Crooked Creek (Kuskokwim basin), description of..... 300–301, 351
gold on..... 351–353
production of..... 353
Crooked Creek (Little Nelchina basin), gold on..... 127–128
Cub Bear (iron) group, description of..... 365
Culross Island, mining on..... 139
Cymru mine, development work in..... 42

D.

Daisy Creek, gold placers on..... 129
Dall, W. H., on mercury deposits..... 272–273
Dan Creek, gold on..... 104, 115–116
Deadman fraction, description of..... 208
Deadwood Creek basin, mining in..... 61
Ditch waters, thawing with..... 368–369
Dome Creek (Cripple Creek basin), gold on.. 349
Dome Creek (Fairbanks district), placer mining on..... 232
Dominion Creek basin, description of..... 336–337
geology of..... 338
gold of..... 338–339
Dredging, average gold recovery from..... 75, 78
progress of..... 16, 23–24, 62–63, 68–69
Drift mining, average gold recovery from.... 78
Dry Gulch, gold on..... 222–223, 225
Dunton mine, operations in..... 42

E.

Eagle precinct, mining operations in..... 63–64
Eagle River mine, development in..... 101
Eaglek Bay, discoveries on..... 139
Eakin, H. M., iron-ore deposits near Nome. 361–365
on mining in the Fairbanks district ... 229–238
on mining in the Hot Springs district.. 239–245
on mining in the Juneau region..... 95–102
on the Wilson Creek district 65–66
on placer mining in Seward Peninsula. 366–373
on tin mining in Alaska..... 81–94
Ear Mountain region, tin prospects in..... 89
Eek River basin, arsenic in..... 305
gold in..... 301–302, 357
Eldorado Creek, placer mining on..... 232
Ellamar Mining Co., operations by..... 133
Elliott Creek, mining on..... 112–113
Ester Creek, placer mining on..... 234–235, 238
Eureka Creek, description of..... 339
gold of..... 339
Eva Creek, placer mining on..... 235
Everson, Gauthier & Cooper, claim of..... 138

F.

Fairbanks Creek, lode mines on..... 237
placer mining on..... 233
prospecting on..... 237–238
Fairbanks district, gold of, production of, 1903 to 1914..... 53–54
mining in 55, 239–245
cost of..... 54–55, 78
prospecting in..... 237
silver of, production of, 1903–4..... 53–54
Fairhaven district, placer mining in..... 371–372
Fall Creek, mining operations on..... 109
Faro Creek, gold of..... 358
February group, description of..... 360

Page.

Fidalgo Mining Co., development work by.. 134
Field work, record of..... 7–8
Fish Creek, placer mining on..... 233
Fisher Creek, description of..... 346–347
gold on..... 347
Flat Creek, dredging on..... 56, 260
Fortyfive prospect, description of..... 166–167
Fortymile district, dredging in..... 62–63
gold tenor of gravels of..... 76
mining in..... 62–63
Fourth of July Creek, prospecting on..... 129

G.

Galena, production of..... 20
Galena (iron) group, description of..... 364–365
Garnet, mining of..... 21
Geographic distribution of investigations.... 10–13
Geological Survey, U. S., publications of, list of..... I–XI
publications of, progress of..... 14
George River, gold on..... 261, 300–301, 351–352
Georgetown, settlement of..... 301, 303
Giffin, C. E., work of..... 190
Glaciation, evidence of, in the Nelchina-Susitna region..... 119–121
Glacier Creek, gold on..... 223
Glacier Island, copper mining on..... 134
Glen Gulch, antimony at..... 267
cinnabar at..... 287
Gold, lode deposits of..... 96, 98–99
Gold, mining of, in 1914..... 21–24
Gold, placer deposits of..... 91–93
conditions favoring formation of..... 225–226
production of, 1880–1914..... 17, 18–20, 69–70
recovery of..... 73–79
Gold, sources of..... 71–72
Gold Bluff claim, description of..... 182
Gold Bullion mine, operations at..... 48
Gold Creek, gold placers on..... 130
Golden, mining near..... 135
Golden Eagle claim, development on..... 135–136
Gold Hill, source of gold at..... 204–207
Gold King mine, description of..... 183–185
Gold Mountain group, mining on..... 42
Gold Run, gold placers on..... 218–219
Gold Standard property, development on.... 42
Goldstream Creek, placer mining on..... 234
Goodnews district, description of..... 357
gold of..... 357–358
Government railroad, benefits of..... 15
Granby Consolidated Mining, Smelting & Power Co., development by..... 42
Granite Creek, gold on..... 331
Granite mine, description of..... 136–138
Granite Peak, mining operations near..... 110
Grant Lake mine, operations at..... 46
Graphite, mining of..... 21
occurrence of..... 67
Gravels, auriferous, distribution of..... 71–73
gold content of..... 73–79
Grouse Creek, tin placers on..... 89, 91
Guthrie & Belloli claims, description of..... 181
Gypsum, mining of..... 21

H.

Hammond River, mining on..... 58–59
Hamshaw, F. T., claims of..... 211–213
Harrington, G. L., work of..... 140

Page.

Healy River basin, description of..... 50–51
location of, map showing..... 50
mining in..... 65
Hecla claim, description of..... 170
Hickey prospect, description of..... 167–168
High Grade claim, description of..... 166
Hokeley Gulch, placer mining in..... 242–243
Holitna River, gold in..... 261–262
Homestake mine, production of..... 237–238
Hood, O. P., report on coal tests by..... 29–30
Hornet claim, work on..... 344–345
Hot springs, mercury deposited by..... 287–288
Hot Springs district, gold of..... 239–245
gold tenor of gravels of..... 75, 79
mining in..... 58
tin in..... 92–94
Hummer Bay prospect, work on..... 138
Hydraulic mining, gold recoveries from..... 77
opportunities for..... 77

I.

Ibex group, description of..... 162
Ida Bell lode, description of..... 87
Iditarod region, coal of..... 268–270
coal of, analysis of..... 269
mercury of..... 286
gravels of..... 56–57
gold of..... 258–261
tenor of..... 76, 78
map, geologic, of..... 259
mining in..... 55–57
See also Lake Clark-Iditarod region.
Igneous rocks, mercury deposited on intrusion of..... 289
Iliamna Lake-Lake Clark basin, gold in... 263–264
Iliamna region, galena of..... 258, 267–268
manganese in..... 258, 268
Independence Gold Mining Co., work of..... 48
Indian River district, mining in..... 60
Innoko district, gold tenor of gravels of..... 76
mining in..... 62
Investigations, geographic distribution of.... 10–13

J.

Jacksina Creek, gold lode on..... 224
Jackson group, development of..... 42
Jaynes, H. L., claims of..... 168–169
Johnson, B. L., on gold and copper deposits of Port Valdez district..... 140–188
on mining on Prince William Sound... 131–139
Johnson Creek. *See* Chathenda Creek.
Jualin mine, development in..... 102
Julian Creek, gold on..... 261
Juneau region, mining in..... 41, 95–102
Juneau district, new map for..... 11
Jurassic rocks, occurrence and character of... 200

K.

Kantishna district, mining in..... 65
Kapon Creek, gold of..... 357
Katalla district, production of petroleum in.. 39, 43
Katz, F. J., on galena of Iliamna region.... 267–268
on Lake Clark-Iliamna Lake basin. 263–264, 266
on Mulchatna basin..... 263
Kenai Peninsula, gold tenor of gravels of..... 78
mining on..... 45–46
Kennicott formation, position and character of..... 107

Page.

Kensington mine, development in..... 101-102
Kenyon Creek, gold on..... 51
Ketchikan district, marble mines of..... 43
mining in..... 41-43
Kijik River, gold lode on..... 264
molybdenite on..... 258, 268
Kluvesna River, mining operations on..... 109
Knight Island, copper mining on..... 132-133
Knopf, Adolph, on tin lodes of Lost River... 84-86
Kobuk region, mining operations in..... 68
Kodiak Island, mining on..... 47
Kolmakof, mercury near..... 280-286
mercury near, geology of..... 281-282
mineralization of..... 283-286
Kotsina-Kuskulana district, copper in..... 105-114
description of..... 103-105
geology of..... 106-107
gold in..... 109, 115
map, geologic, of..... 108
mining in..... 109, 111
mineral resources of, report on..... 103-117
Kougarok district, placer mining in..... 372
Kowkow Creek, gold of..... 358
Koyuk River district, placer mining in..... 371
Koyukuk district, gold tenor of gravels of.... 76, 79
mining in..... 56-60
costs of..... 59
Kuethluk River basin, copper in..... 304
gold in..... 302, 356-357
Kuskokwim Mountains, coal in..... 305
description of..... 296-298
gold in..... 304
glaciation in..... 298
topography of..... 297-298
Kuskokwim region, description of..... 295-296
economic conditions in..... 302-303
field work in..... 12
geography of..... 295-298
gold of..... 261-262, 265, 303-358
mercury deposits of..... 272-291
history of..... 272-274
origin of..... 287-288
See also Parks prospect; Kolmakof.
mineral deposits of, history of..... 298-358
mining in..... 66-67
prospecting in..... 306
Kuskokwim River, description of..... 280-281
section on, figure showing..... 283
Kuskokwim River, lower, gold placers of, report on..... 292-358
Kuskulana Glacier, mining near..... 113-114
Kuskulana-Kotsina region. *See* Kotsina-Kuskulana region.
Kuskulana River, mining on..... 113, 114

L.

Lake Clark-Iditarod region, access to..... 254-255
antimony in..... 258, 266-267
coal in..... 258, 268-270
copper in..... 257-258, 266
economic conditions in..... 252-256
field work in..... 12
geography of..... 247, 248-250
geology of..... 250-252
gold of..... 257, 260-266
mercury in..... 257
mineral resources of, report on..... 247-271
water resources of..... 270-271

Page.

Lake Clark-Iliamna Lake basin, gold in.... 263-264
Landlocked Bay, work at..... 133
Latouche Island, copper mining on..... 132
Latouche Copper Mining Co., development by..... 132-133
Lignite, occurrence and character of..... 227-228
Lime Creek, mining operations on..... 111
Lindgren, Waldemar, on cinnabar deposits.. 287
Little Eldorado Creek, gold placers on..... 216-217
Little Nelchina River, prospecting on..... 129
Little Oshetna River, gold placers on..... 130
Livengood Creek, gold on..... 51
location of, map showing..... 52
Lode mining, increase of..... 70
Long Creek, mining on..... 57
Lost River (tin) mine, description of..... 84-88
Lost River region, geography of..... 84
geology of..... 84-85
tin of..... 84-88

M.

McCarthy Creek, mining operations on..... 115
McCaskey, H. D., on mercury production.. 290-291
Maddren, A. G., on copper in the Russian Mountains..... 358-360
on gold placers of lower Kuskokwim.. 292-358
on Iditarod district..... 56-57
on stibnite in Lake Clark-Iditarod region. 267
work of..... 272
See also Smith and Maddren.
Magnetite, occurrence of..... 113, 114
Malachite, occurrence of..... 107-108, 111, 112
Mammoth Creek basin, mining in..... 60-61
Manganese, occurrence of..... 253, 268
Marble, production of..... 21
Marvel Creek, description of..... 339-340
geology of..... 340-341
gold of..... 301, 341, 343-346
production of..... 344-346
gravels of..... 341-343
Matanuska field, coal from, test of..... 27-30
placer mining in..... 49
See also Susitna-Matanuska region.
Mayfield Gold Mining Co., claims of..... 185-186
Mercury, production of..... 21, 67, 290-291
production of, economic conditions affecting..... 290-291
Mercury deposits, distribution of, in Alaska. 272
in Kuskokwim region..... 272-291
mining of..... 21, 67
origin of..... 287-288
Mertie, J. B., work of..... 284
Midas (copper) mine, description of..... 187-188
production of..... 151-152
work at..... 45
Midnight Sun claim, work on..... 244
Miller Gulch, placer mining in..... 243-244
Mineral Creek, claims on..... 163-170
mining on..... 109-110
Mineral Creek Mining Co., claims of..... 165-166
Mineral King claim, description of..... 138, 168
Mineral water, shipments of..... 21
Minerals, production of, from 1880 to 1914.... 16-24
Mining, mixed, average gold recovery from.. 78
Minnie claim, description of..... 180
Moffit, F. H., on mineral deposits of the Kotsina-Kuskulana district.... 103-117
Mogul (iron) group, description of..... 364

Page.
Molybdenite, occurrence of..... 268, 268
Monarch (iron) group, description of..... 362–364
iron of, analysis of..... 363
Monte Carlo prospect, description of..... 168
Moore Creek, gold of..... 261
Moose Pass region, mining operations in..... 46
Mountain King mine, description of..... 163–164
Mulchatna River basin, gold deposits of..... 262–263, 265

N.

Navy Department, tests of coal by..... 25–30
Nelchina River, gold of..... 44
Nelchina-Susitna district, field work in..... 119
geography of..... 119–124
geologic map of..... 124
geology of..... 124–125
gold of..... 119, 125–130
report on..... 118–130
surveys of..... 118–119
New York Creek, description of..... 353–354
gold of..... 353–355
Nickel, occurrence of..... 67
Nikolai greenstone, copper minerals in..... 108, 109, 110, 111, 112, 113, 114
distribution of..... 106
Nizina district, mining in..... 44, 114–117
Nome, iron-ore district near, geography of. 361–362
geology of..... 362
iron deposits of..... 362–365
Nome district, dredging in..... 366–367
placer mining in, report on..... 266–370
thawing in..... 268–369
Nugget claim, lead discovered on..... 135
Nugget Creek, mining on..... 113

O.

Ophir Creek, description of..... 332–333
geology of..... 333–334
gold of..... 334–336
gravels of..... 333–334
Orca group, character of..... 144
Oshetna River, mining on..... 130
Otter Creek, dredging on..... 56, 260
Owl prospect, description of..... 180–181

P.

Parks (cinnabar) prospect, description of.. 274–280
geology of..... 275–278
stibnite at..... 279
Passage Canal, gold on..... 138
Pedro Creek, placer mining on..... 234
Peluk Creek, tin placers on..... 90
Petrof, Ivan, on mercury deposits..... 273
Petroleum, consumption of, from 1905 to 1914. 39
production of..... 21
Pigot Bay, gold on..... 138
Pinochle mine, description of..... 161–162
Placer mining, decline of..... 70
production from, 1880–1914..... 69–70
Pleasant Camp, gold near..... 44
Poorman Creek, gold placers on..... 128–129, 219–220
mining on..... 58
Porcupine district, mining in..... 44, 113
Port Clarence district, placer mining in..... 372–373
Port Fidalgo, copper mining at..... 133–134

Page.
Port Valdez district, commercial conditions in..... 141–143
copper ores of..... 151–153
character of..... 157–158
distribution of..... 153–155
geologic relations of..... 155–156
field work in..... 12
geography of..... 140–142
geology of..... 143–151
glaciers of..... 141
gold and copper of, paper on..... 140–188
gold placer deposits of..... 158–159, 186–187
gold lodes of..... 151–155
character of..... 157–158
distribution of..... 153–155
geologic relations of..... 155–156
map of..... 186
mineral resources of..... 151–188
mines and prospects of..... 159–188
Port Wells district, mining in..... 134–139
Potato Mountain, tin near..... 89
Precious metals, statistics on, collection of ... 13
Prince William Sound, copper of..... 131–134
field work on..... 12
gold of..... 134–139
map of..... 138
mining near..... 45, 131–139
Publications, Survey, on Alaska, list of..... I–XI
progress of..... 14
Pyrite, occurrence of..... 109, 110, 112, 113, 114, 115

Q.

Quartz Creek, placer mining on..... 244–245
Quartz Gulch, gold on..... 352
Quicksilver. *See* Mercury.
Queen of Sheba claim, description of..... 170
Quitsch prospect, description of..... 167

R.

Railroads, need for..... 15, 104, 105
Rainy Creek, gold of..... 357
Rambler Gold Mining Co., claims of..... 183
Rampart district, mining in..... 64
Ramsay-Rutherford Gold Mining Co., mine of..... 159–161
Raspberry Island, gold on..... 47
Ready Bullion Creek, placer mining on..... 235
Rex Creek, mining on..... 116–117
Rhoads-Hall mine, work on..... 236
Roaring Creek, gold placers on..... 130
mining on..... 110–111
Robin Creek, description of..... 337
geology of..... 338
gold of..... 338–339
Rose Johnson claims, description of..... 162–163
Roy Lode mine, work at..... 237
Ruby district, gold tenor of gravels of..... 76, 78, 79
mining in..... 57–58
Ruby Gulch, gold of..... 353
Rush & Brown mine, operations in..... 41
Russian Mountains, access to..... 360
copper of..... 67, 300, 304, 359–360
geology of..... 359
mineralization of..... 359
topography of..... 358–359

S.

Page.

Salmon Creek, water power on..... 99-101
Sargent, R. H., work of..... 248
Sawmill Bay area, map of..... 144
Seacoast Mining Co., claims of..... 178-179
Sealey-Davis Mining Co., claims of..... 174-175
Seventymile Creek basin, mining in..... 64
Seward Peninsula, dredging in..... 68-69, 367-373
field work in..... 13
gold tenor of gravels of..... 75, 78
mining in..... 67-68
placer mining in..... 366-373
Shoup Bay, mines near..... 170-183
Silver, mining of, in 1914..... 21-22
production of, from 1880 to 1914..... 17, 19-20
Silver Bow Basin, gold lodes in..... 98-99
Sitka district, mining in..... 43
Silver Gem claim, description of..... 179
Silver-lead deposits. *See* Galena.
Skeen-Lechner mine, operations at..... 46
Skookum Creek, gold placers on..... 217-218
Smith, P. S., on mineral resources of Lake Clark-Iditarod region..... 247-271
work of..... 272
Smith, P. S., and Maddren, A. G., on quicksilver of Kuskokwim region..... 272-291
Snow Gulch, gold of..... 222, 352
Solomon district, placer mining in..... 370
Solomon Gulch, mines in..... 187-188
Soo Mining Co., work of..... 236
South Creek, prospecting on..... 129
Springs, hot, mercury deposited by..... 287-288
Spruce Creek, description of..... 321-326
geology of..... 327
gold on..... 311-312, 323-326, 328-330
production of..... 329-330
Spurr, J. E., on gold of Kuskokwim River... 262
on gold of Mulchatna River..... 262
on mercury deposits..... 273-274
Stibnite, occurrence and character of..... 67, 279
See also Antimony.
Sullivan Creek basin, placer mining in..... 242-245
tin in..... 92, 240-241
Sunshine Creek, mining operations on..... 110
Survey publications on Alaska, list of..... I-XI
progress of..... 14
Surveys, progress of..... 9
Susitna-Matanuska region, mining in..... 47-49
Susitna-Nelchina region. *See* Nelchina-Susitna region.
Susitna River basin, field work in..... 11-12
gold tenor of gravels of..... 76
Sutter Creek, tin placers on..... 89, 91
Sweepstakes Creek, gold on..... 371

T.

Tacotna River, supply station on..... 303
Tatalina River basin, mining in..... 67
Tenderfoot district, placer mining in..... 235
Tertiary rocks, occurrence and character of. 200-201
Thawing, new method of..... 368-369
Thompson-Ford Mining Co., claims of..... 177
Three in One group, description of..... 176-177
Tiger claim, description of..... 170
Tin deposits, bibliography of..... 82-83
development of..... 16
discovery of..... 81-82
Tin deposits, distribution of..... 81-82
map showing..... 82
dredging for..... 91, 92, 372
lode deposits of..... 85-86, 87, 89
placer deposits of..... 89-93
production of, from 1902 to 1914..... 17, 20, 82
Tin mining in Alaska, report on..... 81-94
Tiny Gulch, gold on..... 312
Togiak Bay, beach placers on..... 358
Tolovana River basin, gold placers in..... 51-53
map of..... 52
Tomboy group, development of..... 138
Trail Creek, gold of..... 358
Transportation, progress of..... 16
Treadwell mines, operations in..... 41, 96-97
production in, 1882-1914..... 97
Triassic rocks, occurrence and character of. 199-200
Tuluksak River, description of..... 307-308
gold of..... 300
Tuluksak-Aniak district, geography of..... 307-309
gold of..... 309-351
location of..... 292, 306-307
map of..... 358
Tungsten, occurrence of..... 67, 85, 85-86
Twin Creek, mining on..... 233, 238

V.

Valdez, description of..... 142
Valdez Creek district, mining in..... 49
Valdez Glacier area, mines of..... 159-163
Valdez group, character of..... 144
Valdez Mining Co., mines of..... 162
Valparaiso mine, development work in..... 42
Vault Creek, placer mining on..... 233
Volcanic ash, occurrence and character of.. 201-202
shipments of..... 21
Von Gunther prospect, description of..... 167

W.

Wells, R. C., tests of cinnabar by..... 279
Wells Bay, copper mining on..... 134
White Creek, mining operations on..... 117
White River-Chisana district. *See* Chisana-White River district.
Wild Horse claim, work on..... 344-345
Williams, R. Y., on coal tests..... 25-26
Williams-Gentzler prospect, description of... 164
Willow Creek district, mining operations in..... 48-49, 238
prospecting in..... 129
Wilson Creek. *See* Chavolda Creek.
Wilson Creek district, mining in..... 65-66
Wolframite, occurrence of..... 85-86
Woodchopper Creek basin, mining in..... 61-62
Wrangell district, mining operations in..... 44

Y.

Yacko Creek, gold placers on..... 129
Yakataga district, mining operations in..... 43
Yellow Jacket claim, work on..... 238, 344, 345
Yellow River, gold rush to..... 299-300
Yentna district, gold tenor of gravels of..... 78
mining in..... 49
York region, map of.....
tin mining in..... 83-92
Yukon basin, field work in..... 13
gold tenor of gravels of..... 77, 78
production of gold and silver in..... 49-50

RECENT SURVEY PUBLICATIONS ON ALASKA.

[Arranged geographically. A complete list can be had on application.]

All these publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained free of charge (except certain maps) on application.

2. A certain number are delivered to Senators and Representatives in Congress for distribution.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost. The publications marked with an asterisk (*) in this list are out of stock at the Survey, but can be purchased from the Superintendent of Documents at the prices stated.

4. Copies of all Government publications are furnished to the principal public libraries throughout the United States, where they can be consulted by those interested.

GENERAL.

REPORTS.

*The geography and geology of Alaska, a summary of existing knowledge, by A. H. Brooks, with a section on climate, by Cleveland Abbe, jr., and a topographic map and description thereof, by R. U. Goode. Professional Paper 45, 1906, 327 pp. $1.

Placer mining in Alaska in 1904, by A. H. Brooks. In Bulletin 259, 1905, pp. 18–31.

The mining industry in 1905, by A. H. Brooks. In Bulletin 284, 1906, pp. 4–9.

The mining industry in 1906, by A. H. Brooks. In Bulletin 314, 1907, pp. 19–39.

*The mining industry in 1907, by A. H. Brooks. In Bulletin 345, 1908, pp. 30–53. 45 cents.

*The mining industry in 1908, by A. H. Brooks. In Bulletin 379, 1909, pp. 21–62. 50 cents.

The mining industry in 1909, by A. H. Brooks. In Bulletin 442, 1910, pp. 20–46.

The mining industry in 1910, by A. H. Brooks. In Bulletin 480, 1911, pp. 21–42.

*The mining industry in 1911, by A. H. Brooks. In Bulletin 520, 1912, pp. 19–44 50 cents.

The mining industry in 1912, by A. H. Brooks. In Bulletin 542, 1913, pp. 18–51.

*The Alaskan mining industry in 1913, by A. H. Brooks. In Bulletin 592, 1914, pp. 45–74.

*The Alaskan mining industry in 1914, by A. H. Brooks. In Bulletin 622, 1915, pp. 15–68.

*Railway routes, by A. H. Brooks. In Bulletin 284, 1906, pp. 10–17.

*Railway routes from the Pacific seaboard to Fairbanks, Alaska, by A. H. Brooks.

*Geologic features of Alaskan metalliferous lodes, by A. H. Brooks. In Bulletin 480, 1911, pp. 43–93.

*The mineral deposits of Alaska, by A. H. Brooks. In Bulletin 592, 1914, pp. 18–44.

*The future of gold placer mining in Alaska, by A. H. Brooks. In Bulletin 622, 1915, pp. 69–79.

*Tin resources of Alaska, by F. L. Hess. In Bulletin 520, 1912, pp. 89–92. 50 cents.

Tin mining in Alaska, by H. M. Eakin. In Bulletin 622, 1915, pp. 81–94.

Administrative report, by A. H. Brooks. In Bulletin 259, 1905, pp. 13–17.

Administrative report, by A. H. Brooks. In Bulletin 284, 1906, pp. 1–3.

Administrative report, by A. H. Brooks. In Bulletin 314, 1907, pp. 11–18.

*Administrative report, by A. H. Brooks. In Bulletin 345, 1908, pp. 5–17. 45 cents.

*Administrative report, by A. H. Brooks. In Bulletin 379, 1909, pp. 5–20. 50 cents.

Administrative report, by A. H. Brooks. In Bulletin 442, 1910, pp. 5–19.

Administrative report, by A. H. Brooks. In Bulletin 480, 1911, pp. 5–14.

*Administrative report, by A. H. Brooks. In Bulletin 520, 1912, pp. 7–18. 50 cents.

Administrative report, by A. H. Brooks. In Bulletin 542, 1913, pp. 7–17.

Administrative report, by A. H. Brooks. In Bulletin 592, 1914, pp. 7–17.

Administrative report, by A. H. Brooks. In Bulletin 622, 1915, pp. 7–14.

Report on progress of surveys of public lands in Alaska during 1910, by A. H. Brooks. In Bulletin 480, 1911, pp. 15–20.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.

Alaska coal and its utilization, by A. H. Brooks. Bulletin 442J, reprinted 1914.

*The possible use of peat fuel in Alaska, by C. A. Davis. In Bulletin 379, 1909, pp. 63–66. 50 cents.

The preparation and use of peat as a fuel, by C. A. Davis. In Bulletin 442, 1910, pp. 101–132.

Methods and costs of gravel and placer mining in Alaska, by C. W. Purington. Bulletin 263, 1905, 362 pp. (Abstract in Bulletin 259, 1905, pp. 32–46.)

*Prospecting and mining gold placers in Alaska, by J. P. Hutchins. In Bulletin 345, 1908, pp. 54–77. 45 cents.

*Geographic dictionary of Alaska, by Marcus Baker; second edition prepared by James McCormick. Bulletin 299, 1906, 690 pp. 50 cents.

MAPS.

*Map of Alaska showing contours; scale 1:2,500,000; 1906, by R. U. Goode and E. C. Barnard. In * Professional Paper 45. $1. Not issued separately.

Map of Alaska; scale 1:5,000,000; 1912; by Alfred H. Brooks. 20 cents.

Map of Alaska; scale 1:1,500,000; 1915; by A. H. Brooks and R. H. Sargent. 80 cents.

Map of Alaska showing distribution of mineral deposits; scale, 1:5,000,000; by A. H. Brooks. 20 cents. Also included in * Bulletin 520. 50 cents. (New edition included in Bulletin 592.)

SOUTHEASTERN ALASKA.

REPORTS.

*The Porcupine placer district, Alaska, by C. W. Wright. Bulletin 236, 1904, 35 pp. 15 cents.

Economic developments in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin 259, 1905, pp. 47–68.

*The Juneau gold belt, Alaska, by A. C. Spencer, pp. 1–137, and A reconnaissance of Admiralty Island, Alaska, by C. W. Wright, pp. 138–154. Bulletin 287, 1906, 161 pp. 75 cents.

Lode mining in southeastern Alaska, by F. E. and C. W. Wright. In Bulletin 284, 1906, pp. 30–53.

Nonmetallic deposits of southeastern Alaska, by C. W. Wright. In Bulletin 284, 1906, pp. 54–60.

Lode mining in southeastern Alaska, by C. W. Wright. In Bulletin 314, 1907, pp. 47–72.

Nonmetalliferous mineral resources of southeastern Alaska, by C. W. Wright. In Bulletin 314, 1907, pp. 73–81.

Reconnaissance on the Pacific coast from Yakutat to Alsek River, by Eliot Blackwelder. In Bulletin 314, 1907, pp. 82–88.

*Lode mining in southeastern Alaska, 1907, by C. W. Wright. In Bulletin 345, 1908, pp. 78–97. 45 cents.

*The building stones and materials of southeastern Alaska, by C. W. Wright. In Bulletin 345, 1908, pp. 116–126. 45 cents.

*The Ketchikan and Wrangell mining districts, Alaska, by F. E. and C. W. Wright. Bulletin 347, 1908, 210 pp. 60 cents.

*The Yakutat Bay region, Alaska: Physiography and glacial geology, by R. S. Tarr; Areal geology, by R. S. Tarr and B. S. Butler. Professional Paper 64, 1909, 186 pp. 50 cents.

*Mining in southeastern Alaska, by C. W. Wright. In Bulletin 379, 1909, pp. 67–86. 50 cents.

Mining in southeastern Alaska, by Adolph Knopf. In Bulletin 442, 1910, pp. 133–143.

Occurrence of iron ore near Haines, by Adolph Knopf. In Bulletin 442, 1910, pp. 144–146.

Report of water-power reconnaissance in southeastern Alaska, by J. C. Hoyt. In Bulletin 442, 1910, pp. 147–157.

Geology of the Berners Bay region, Alaska, by Adolph Knopf. Bulletin 446, 1911, 58 pp.

Mining in southeastern Alaska, by Adolph Knopf. In Bulletin 480, 1911, pp. 94–102.

The Eagle River region, by Adolph Knopf. In Bulletin 480, 1911, pp. 103–111.

The Eagle River region, southeastern Alaska, by Adolph Knopf. Bulletin 502, 1912, 61 pp.

The Sitka mining district, Alaska, by Adolph Knopf. Bulletin 504, 1912, 32 pp.

The earthquakes at Yakutat Bay, Alaska, in September, 1899, by R. S. Tarr and Lawrence Martin, with a preface by G. K. Gilbert. Professional Paper 69, 1912, 135 pp.

Marble resources of Ketchikan and Wrangell districts, by E. F. Burchard. In Bulletin 542, 1913, pp. 52–77.

Marble resources of the Juneau, Skagway, and Sitka districts, by E. F. Burchard. In Bulletin 592, 1914, pp. 95–107.

A barite deposit near Wrangell, by E. F. Burchard. In Bulletin 592, 1914, pp. 109–117.

Lode mining in the Ketchikan district, by P. S. Smith. In Bulletin 592, 1914, pp. 75–94.

The geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska, by C. W. Wright. Professional Paper 87, 1915, 110 pp.

Mining in Juneau region (1914), by H. M. Eakin. In Bulletin 622, 1915, pp.

Mining in the Juneau region [1914], by H. M. Eakin. In Bulletin 622, 1915, pp. 95–102.

TOPOGRAPHIC MAPS.

*Juneau gold belt, Alaska; scale, 1:250,000; compiled. In *Bulletin 287. 75 cents. Not issued separately.

Juneau special (No. 581A); scale, 1:62,500; by W. J. Peters. 10 cents each, or $3 for 50.

Berners Bay special (No. 581B); scale, 1:62,500; by R. B. Oliver. 10 cents each, or $3 for 50.

Kasaan Peninsula, Prince of Wales Island (No. 540A); scale, 1:62,500; by D. C. Witherspoon, R. H. Sargent, and J. W. Bagley. 10 cents each, or $3 for 50.

Copper Mountain and vicinity, Prince of Wales Island (No. 540B); scale, 1:62,500; by R. H. Sargent. 10 cents each, or $3 for 50.

Eagle River region (No. 581C); scale, 1:62,500; by J. W. Bagley, C. E. Giffin, and R. E. Johnson. In Bulletin 502. Not issued separately.

CONTROLLER BAY, PRINCE WILLIAM SOUND, AND COPPER RIVER REGIONS.

REPORTS.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.

Geology of the central Copper River region, Alaska, by W. C. Mendenhall. Professional Paper 41, 1905, 133 pp.

*Geology and mineral resources of Controller Bay region, Alaska, by G. C. Martin. Bulletin 335, 1908, 141 pp. 70 cents.

*Notes on copper prospects of Prince William Sound, by F. H. Moffit. In Bulletin 345, 1908, pp. 176–178. 45 cents.

Mineral resources of the Kotsina-Chitina region, by F. H. Moffit and A. G. Maddren. Bulletin 374, 1909, 103 pp.

*Copper mining and prospecting on Prince William Sound, by U. S. Grant and D. F. Higgins, jr. In Bulletin 379, 1909, pp. 87–96. 50 cents.

*Gold on Prince William Sound, by U. S. Grant. In Bulletin 379, 1909, p. 97. 50 cents.

*Mining in the Kotsina-Chitina, Chistochina, and Valdez Creek regions, by F. H. Moffit. In Bulletin 379, 1909, pp. 153–160. 50 cents.

Mineral resources of the Nabesna-White River district, by F. H. Moffit and Adolph Knopf; with a section on the Quaternary, by S. R. Capps. Bulletin 417, 1910, 64 pp.

Mining in the Chitina district, by F. H. Moffit. In Bulletin 442, 1910, pp. 158–163.

Mining and prospecting on Prince William Sound in 1909, by U. S. Grant. In Bulletin 442, 1910, pp. 164–165.

Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska, by U. S. Grant and D. F. Higgins. Bulletin 443, 1910, 89 pp.

Geology and mineral resources of the Nizina district, Alaska, by F. H. Moffit and S. R. Capps. Bulletin 448, 1911, 111 pp.

Headwater regions of Gulkana and Susitna rivers, Alaska, with accounts of the Valdez Creek and Chistochina placer districts, by F. H. Moffit. Bulletin 498, 1912, 82 pp.

*The Chitina district, by F. H. Moffit. In Bulletin 520, 1912, pp. 105–107. 50 cents.

*Gold deposits near Valdez, by A. H. Brooks. In Bulletin 520, 1912, pp. 108–130. 50 cents.

Coastal glaciers of Prince William Sound and Kenai Peninsula, Alaska, by U. S. Grant and D. F. Higgins. Bulletin 526, 1913, 75 pp.

The McKinley Lake district, by Theodore Chapin. In Bulletin 542, 1913, pp. 78–80.

Mining in Chitina Valley, by F. H. Moffit. In Bulletin 542, 1913, pp. 81–85.

Mineral deposits of the Ellamar district, by S. R. Capps and B. L. Johnson. In Bulletin 542, 1913, pp. 86–124.

The mineral deposits of the Yakataga region, by A. G. Maddren. In Bulletin 592, 1914, pp. 119–154.

Preliminary report on water power of south-central Alaska, by C. E. Ellsworth and Royal W. Davenport. In Bulletin 592, 1914, pp. 155–194.

The Port Wells gold-lode district, by B. L. Johnson. In Bulletin 592, 1914, pp. 195–236.

Mining on Prince William Sound, by B. L. Johnson. In Bulletin 592, 1914, pp. 237–244.

Geology of the Hanagita-Bremner region, by F. H. Moffit. Bulletin 576, 1915, 56 pp.

The geology and mineral resources of Kenai Peninsula, by G. C. Martin, B. L. Johnson, and U. S. Grant. Bulletin 587, 1915, 243 pp.

Mineral deposits of the Kotsina-Kuskulana district, with notes on mining in Chitina Valley, by Fred H. Moffit. In Bulletin 622, 1915, pp. 103–117.

Auriferous gravels of the Nelchina-Susitna region, by Theodore Chapin. In Bulletin 622, 1915, pp. 118–130.

Mining on Prince William Sound [1914], by B. L. Johnson. In Bulletin 622, 1915, pp. 131–139.

The gold and copper deposits of the Port Valdez district, by B. L. Johnson. In Bulletin 622, 1915, pp. 140–188.

In press.

The Ellamar district, by S. R. Capps and B. L. Johnson. Bulletin 605.

A water-power reconnaissance in south-central Alaska, by C. E. Ellsworth and Royal W. Davenport. Water-Supply Paper 372.

In preparation.

The Kotsina-Kuskulana district, by F. H. Moffit.

TOPOGRAPHIC MAPS.

Central Copper River region; reconnaissance map; scale, 1:250,000; by T. G. Gerdine. In Professional Paper 41. Not issued separately.

Headwater regions of Copper, Nabesna, and Chisana rivers; reconnaissance map; scale, 1:250,000; by D. C. Witherspoon, T. G. Gerdine, and W. J. Peters. In Professional Paper 41. Not issued separately.

Controller Bay region; scale, 1:62,500; by E. G. Hamilton and W. R. Hill. 35 cents. No wholesale rate.

Chitina quadrangle; reconnaissance map; scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, and others. In Bulletin 576.

Nizina district; scale 1:62,500; by D. C. Witherspoon and R. M. La Follette. In Bulletin 448. Not issued separately.

Headwater region of Gulkana and Susitna rivers; scale, 1:250,000; by D. C. Witherspoon, J. W. Bagley, and C. E. Giffin. In Bulletin 498. Not issued separately.

Prince William Sound; scale, 1:500,000; compiled. In Bulletin 526. Not issued separately.

Port Valdez district; scale, 1:62,500; by J. W. Bagley. Price 20 cents.
The Bering River coal fields; scale, 1:62,500; by G. C. Martin. Price, 25 cents.

In preparation.

The Ellamar district; by R. H. Sargent and C. E. Giffin; scale 1:62,500.
The Kotsina-Kuskulana district; scale 1:62,500; by D. C. Witherspoon.

COOK INLET AND SUSITNA REGION.

REPORTS.

The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.
Geologic reconnaissance in the Matanuska and Talkeetna basins, Alaska, by Sidney Paige and Adolph Knopf. Bulletin 327, 1907, 71 pp.
Gold placers of the Mulchatna, by F. J. Katz. In Bulletin 442, 1910, pp. 201–202.
The Mount McKinley region, Alaska, by A. H. Brooks, with descriptions of the igneous rocks and of the Bonnifield and Kantishna districts, by L. M. Prindle. Professional Paper 70, 1911, 234 pp.
A geologic reconnaissance of the Iliamna region, Alaska, by G. C. Martin and F. J. Katz. Bulletin 485, 1912, 138 pp.
Geology and coal fields of the lower Matanuska Valley, Alaska, by G. C. Martin and F. J. Katz. Bulletin 500, 1912, 98 pp.
The Yentna district, Alaska, by S. R. Capps. Bulletin 534, 1913, 75 pp.
Gold lodes and placers of the Willow Creek district, by S. R. Capps. In Bulletin 592, 1914, pp. 245–272.
Mineral resources of the Upper Matanuska and Nelchina valleys, by G. C. Martin and J. B. Mertie, jr. In Bulletin 592, 1914, pp. 273–300.
Preliminary report on the Broad Pass region, by F. H. Moffit. In Bulletin 592, 1914, pp. 301–306.
Mining in the Valdez Creek placer district, by F. H. Moffit. In Bulletin 592, 1914, pp. 307–308.
The geology and mineral resources of Kenai Peninsula, Alaska, by G. C. Martin, B. L. Johnson, and U. S. Grant. Bulletin 587, 1915, 243 pp.

In press.

The Willow Creek district, by S. R. Capps. Bulletin 607.
The Broad Pass region, by F. H. Moffit and J. E. Pogue. Bulletin 608.

TOPOGRAPHIC MAPS.

Kenai Peninsula, southern portion; scale, 1:500,000; compiled. In Bulletin 526. Not issued separately.
Matanuska and Talkeetna region, reconnaissance map; scale, 1:250,000; by T. G. Gerdine and R. H. Sargent. In Bulletin 327. Not issued separately.
Lower Matanuska Valley; scale, 1:62,500; by R. H. Sargent. In Bulletin 500. Not issued separately.
Yentna district, reconnaissance map; scale, 1:250,000; by R. W. Porter. Revised edition. In Bulletin 534. Not issued separately.
Mount McKinley region, reconnaissance map; scale, 1:625,000; by D. L. Reaburn. In Professional Paper 70. Not issued separately.

Kenai Peninsula, reconnaissance map; scale, 1:250,000; by R. H. Sargent, J. W. Bagley, and others. Included in Bulletin 587. Not issued separately.
Moose Pass and vicinity; scale, 1:62,500; by J. W. Bagley. Included in Bulletin 587. Not issued separately.

In preparation.

The Matanuska coal field; scale 1:62,500; by R. H. Sargent.
The Willow Creek district; scale 1:62,500; by C. E. Giffin.
The Broad Pass region; scale 1:250,000; by J. W. Bagley.

SOUTHWESTERN ALASKA.

REPORTS.

*A reconnaissance in southwestern Alaska, by J. E. Spurr. In Twentieth Annual Report, pt. 7, 1900, pp. 31–264. $1.80.
Gold mine on Unalaska Island, by A. J. Collier. In Bulletin 259, 1905, pp. 102–103.
The petroleum fields of the Pacific coast of Alaska, with an account of the Bering River coal deposits, by G. C. Martin. Bulletin 250, 1905, 64 pp.
Geology and mineral resources of parts of Alaska Peninsula, by W. W. Atwood. Bulletin 467, 1911, 137 pp.
A geologic reconnaissance of the Iliamna region, Alaska, by G. C. Martin and F. J. Katz. Bulletin 485, 1912, 138 pp.
Mineral deposits of Kodiak and the neighboring islands, by G. C. Martin. In Bulletin 542, 1913, pp. 125–136.

TOPOGRAPHIC MAPS.

Herendeen Bay and Unga Island region, reconnaissance map; scale, 1:250,000; by H. M. Eakin. In Bulletin 467. Not issued separately.
Chignik Bay region, reconnaissance map; scale, 1:250,000; by H. M. Eakin. In Bulletin 467. Not issued separately.
Iliamna region, reconnaissance map; scale; 1:250,000; by D. C. Witherspoon and C. E. Giffin. In Bulletin 485. Not issued separately.
*Kuskokwim River and Bristol Bay region; scale, 1:625,000; by W. S. Post. In Twentieth Annual Report, pt. 7. $1.80. Not issued separately.

YUKON AND KUSKOKWIM BASINS.

REPORTS.

*The coal resources of the Yukon, Alaska, by A. J. Collier. Bulletin 218, 1903, 71 pp. 15 cents.
*Occurrence of gold in the Yukon-Tanana region, by L. M. Prindle. In Bulletin 345, 1908, pp. 179–186. 45 cents.
The Fortymile quadrangle, Yukon-Tanana region, Alaska, by L. M. Prindle. Bulletin 375, 1909, 52 pp.
Water-supply investigations in Yukon-Tanana region, Alaska, 1907–8 (Fairbanks, Circle, and Rampart districts), by C. C. Covert and C. E. Ellsworth. Water-Supply Paper 228, 1909, 108 pp.
The Innoko gold-placer district, Alaska, with accounts of the central Kuskokwim Valley and the Ruby Creek and Gold Hill placers, by A. G. Maddren. Bulletin 410, 1910, 87 pp.

Mineral resources of Nabesna-White River district, by F. H. Moffit and Adolph Knopf, with a section on the Quaternary by S. R. Capps. Bulletin 417, 1910, pp. 64.

Placer mining in the Yukon-Tanana region, by C. E. Ellsworth. In Bulletin 442, 1910, pp. 230–245.

Occurrence of wolframite and cassiterite in the gold placers of Deadwood Creek, Birch Creek district, by B. L. Johnson. In Bulletin 442. 1910, pp. 246–250.

Placer mining in the Yukon-Tanana region, by C. E. Ellsworth and G. L. Parker. In Bulletin 480, 1911, p. 172.

Gold placer mining developments in the Innoko-Iditarod region, by A. G. Maddren. In Bulletin 480, 1911, pp. 236–270.

*Placer mining in the Fortymile and Seventymile river districts, by E. A. Porter. In Bulletin 520, 1912, pp. 211–218. 50 cents.

*Placer mining in the Fairbanks and Circle districts, by C. E. Ellsworth. In Bulletin 520, 1912, pp. 240–245. 50 cents.

*Gold placers between Woodchopper and Fourth of July creeks, upper Yukon River, by L. M. Prindle and J. B. Mertie, jr. In Bulletin 520, 1912, pp. 201–210. 50 cents.

The Bonnifield region, Alaska, by S. R. Capps. Bulletin 501, 1912, 162 pp.

A geologic reconnaissance of a part of the Rampart quadrangle, Alaska, by H. M. Eakin. Bulletin 535, 1913, 38 pp.

A geologic reconnaissance of the Fairbanks quadrangle, Alaska, by L. M. Prindle, with a detailed description of the Fairbanks district, by L. M. Prindle and F. J. Katz, and an account of lode mining near Fairbanks, by P. S. Smith. Bulletin 525, 1913, 220 pp.

*The Koyukuk-Chandalar region, Alaska, by A. G. Maddren. Bulletin 532. 1913, 119 pp. Price 25 cents.

A geologic reconnaissance of the Circle quadrangle Alaska, by L. M. Prindle. Bulletin 538, 1913, 82 pp.

Placer mining in the Yukon-Tanana region, by C. E. Ellsworth and R. W. Davenport. In Bulletin 542, 1913, pp. 203–222.

The Chisana placer district, by A. H. Brooks. In Bulletin 592, 1914, pp. 309–320.

Placer mining in the Yukon-Tanana region, by Theodore Chapin. In Bulletin 592, 1914, pp. 357–362.

Lode developments near Fairbanks, by Theodore Chapin. In Bulletin 592, 1914, pp. 321–355.

Mineral resources of the Yukon-Koyukuk region, by H. M. Eakin. In Bulletin 592, 1914, pp. 371–384.

The Iditarod-Ruby region, Alaska, by H. M. Eakin. Bulletin 578, 1914, 45 pp.

Surface water supply of the Yukon-Tanana region, 1907 to 1912, by C. E. Ellsworth and R. W. Davenport. Water-Supply Paper 342, 1915, 343 pp.

Mineral resources of the Chisana-White River district, by S. R. Capps. In Bulletin 622, 1915, pp. 189–228.

Mining in the Fairbanks district, by H. M. Eakin. In Bulletin 622, 1915, pp. 229–238.

Mining in the Hot Springs district, by H. M. Eakin. In Bulletin 622, 1915, pp. 239–245.

Mineral resources of the Lake Clark-Iditarod region, by P. S. Smith. In Bulletin 622, 1915, pp. 247–271.

Quicksilver deposits of the Kuskokwim region, by P. S. Smith and A. G. Maddren. In Bulletin 622, 1915, pp. 272–291.

Gold placers of the lower Kuskokwim, with a note on copper in the Russian Mountains, by A. G. Maddren. In Bulletin 622, 1915, pp. 292–360.

In preparation.

Chisana-White River district, by S. R. Capps.
Yukon-Koyukuk region, by H. M. Eakin.
Lake Clark-Iditarod region, by P. S. Smith.

Topographic maps.

Circle quadrangle (No. 641); scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, and others. 50 cents each, or $15 for 50. Also in Bulletin 295.

Fairbanks quadrangle (No. 642); scale, 1:250,000; by T. G. Gerdine, D. C. Witherspoon, R. B. Oliver, and J. W. Bagley. 50 cents each, or $15 for 50. Also in Bulletins *337 (25 cents) and 525.

Fortymile quadrangle (No. 640); scale, 1:250,000; by E. C. Barnard. 10 cents each, or $3 for 50. Also in Bulletin 375.

Rampart quadrangle (No. 643); scale, 1:250,000; by D. C. Witherspoon and R. B. Oliver. 20 cents each, or $6 for 50. Also in Bulletin 337, and part in Bulletin 535.

Fairbanks special (No. 642A); scale, 1:62.500; by T. G. Gerdine and R. H. Sargent. 20 cents each, or $6 for 50. Also in Bulletin 525.

Bonnifield region; scale, 1:250,000; by J. W. Bagley, D. C. Witherspoon, and C. E. Giffin. In Bulletin 501. Not issued separately.

Iditarod-Ruby region, reconnaissance map; scale, 1:250.000; by C. G. Anderson, W. S. Post, and others. In Bulletin 578. Not issued separately.

Middle Kuskokwim and lower Yukon region; scale, 1:500,000; by C. G. Anderson, W. S. Post, and others. In Bulletin 578. Not issued separately.

In preparation.

Yukon-Koyukuk region; scale, 1:500,000; by H. M. Eakin.
Lake Clark-Iditarod region; scale, 1:250,000; by R. H. Sargent.
Lower Kuskokwim region; scale, 1:500,000; by R. H. Sargent.

SEWARD PENINSULA.

REPORTS.

The Fairhaven gold placers of Seward Peninsula, Alaska, by F. H. Moffit. Bulletin 247, 1905, 85 pp.

Gold mining on Seward Peninsula, by F. H. Moffit. In Bulletin 284, 1906, pp. 132–141. The Kougarok region, by A. H. Brooks. In Bulletin 314, 1907, pp. 164–181.

Geology and mineral resources of Iron Creek, by P. S. Smith. In Bulletin 314, 1907, pp. 157–163.

The gold placers of parts of Seward Peninsula, Alaska, including the Nome, Council, Kougarok, Port Clarence, and Goodhope precincts, by A. J. Collier, F. L. Hess, P. S. Smith, and A. H. Brooks. Bulletin 328, 1908, 343 pp.

*Investigation of the mineral deposits of Seward Peninsula, by P. S. Smith. In Bulletin 345, 1908, pp. 206–250. 45 cents.

Geology of the Seward Peninsula tin deposits, by Adolph Knopf. Bulletin 358, 1908, 72 pp.

*Recent developments in southern Seward Peninsula, by P. S. Smith. In Bulletin 379, 1909, pp. 267–301. 50 cents.

*The Iron Creek region, by P. S. Smith. In Bulletin 379, 1909, pp. 302–354. 50 cents.

*Mining in the Fairhaven district, by F. F. Henshaw. In Bulletin 379, 1909, pp. 355–369. 50 cents.

Geology and mineral resources of the Solomon and Casadepaga quadrangles, Seward Peninsula, Alaska, by P. S. Smith. Bulletin 433, 1910, 227 pp.

Mining in Seward Peninsula, by F. F. Henshaw. In Bulletin 442, 1910, pp. 353–371.

A geologic reconnaissance in southeastern Seward Peninsula and the Norton Bay-Nulato region, by P. S. Smith and H. M. Eakin. Bulletin 449, 1911, 146 pp.

*Notes on mining in Seward Peninsula, by P. S. Smith. In Bulletin 520, 1912, pp. 339–344. 50 cents.

Geology of the Nome and Grand Central quadrangles, Alaska, by F. H. Moffit. Bulletin 533, 1913, 140 pp.

*Surface water supply of Seward Peninsula, Alaska, by F. F. Henshaw and G. L. Parker, with a sketch of the geography and geology, by P. S. Smith, and a description of methods of placer mining, by Alfred H. Brooks; including topographic reconnaissance map. Water-Supply Paper 314, 1913, 317 pp. 45 cents.

Placer mining on Seward Peninsula, by Theodore Chapin. In Bulletin 592, 1914, pp. 385–396.

Lode developments on Seward Peninsula, by Theodore Chapin. In Bulletin 592, 1914, pp. 397–407.

Iron-ore deposits near Nome, by Henry M. Eakin. In Bulletin 622, 1915, pp. 361–365.

Placer mining in Seward Peninsula, by Henry M. Eakin. In Bulletin 622, 1915, pp. 366–373.

TOPOGRAPHIC MAPS.

Seward Peninsula, compiled from work of D. C. Witherspoon, T. G. Gerdine, and others, of the Geological Survey, and all available sources; scale, 1:500,000. In Water-Supply Paper 314. Not issued separately.

Seward Peninsula, northeastern portion, reconnaissance map (No. 655); scale, 1:250,000; by D. C. Witherspoon and C. E. Hill. 50 cents each, or $30 a hundred. Also in Bulletin 247.

Seward Peninsula, northwestern portion, reconnaissance map (No. 657); scale, 1:250,000; by T. G. Gerdine and D. C. Witherspoon. 50 cents each, or $30 a hundred. Also in Bulletin 328.

Seward Peninsula, southern portion, reconnaissance map (No. 656); scale, 1:250,000; by C. E. Barnard, T. G. Gerdine, and others. 50 cents each, or $30 a hundred. Also in Bulletin 328.

Seward Peninsula, southeastern portion, reconnaissance map (Nos. 655–656); scale, 1:250,000; by E. C. Barnard, D. L. Reaburn, H. M. Eakin, and others. In Bulletin 449. Not issued separately.

Nulato-Norton Bay region; scale, 1:500,000; by P. S. Smith, H. M. Eakin, and others. In Bulletin 449. Not issued separately.

Grand Central quadrangle (No. 646A); scale, 1:62,500; by T. G. Gerdine, R. B. Oliver, and W. R. Hill. 10 cents each, or $3 for 50. Also in Bulletin 533.

Nome quadrangle (No. 646B); scale, 1:62,500; by T. G. Gerdine, R. B. Oliver, and W. R. Hill. 10 cents each, or $3 for 50. Also in Bulletin 533.

Casadepaga quadrangle (No. 646C); scale, 1:62,500; by T. G. Gerdine, W. B. Corse, and B. A. Yoder. 10 cents each, or $3 for 50. Also in Bulletin 433.

Solomon quadrangle (No. 646D); scale, 1:62,500; by T. G. Gerdine, W. B. Corse, and B. A. Yoder. 10 cents each, or $3 for 50. Also in Bulletin 433.

NORTHERN ALASKA.

REPORTS.

*A reconnaissance in northern Alaska across the Rocky Mountains, along Koyukuk, John, Anaktuvuk, and Colville rivers and the Arctic coast to Cape Lisburne in 1901, by F. C. Schrader, with notes by W. J. Peters Professional Paper 20, 1904, 139 pp. 40 cents.

*Geology and coal resources of the Cape Lisburne region, Alaska, by A. J. Collier. Bulletin 278, 1906, 54 pp. 15 cents.

*Geologic investigations along the Canada-Alaska boundary, by A. G. Maddren. In Bulletin 520, 1912, pp. 297–314. 50 cents.

The Noatak-Kobuk region, by P. S. Smith. Bulletin 536, 1913, 160 pp.

*The Koyukuk-Chandalar region, Alaska, by A. G. Maddren. Bulletin 532, 1913, 119 pp. 25 cents.

TOPOGRAPHIC MAPS.

*Koyukuk River to mouth of Colville River, including John River; scale, 1:1,250,000; by W. J. Peters. In *Professional Paper 20. 40 cents. Not issued separately.

Koyukuk and Chandalar regions, reconnaissance map; scale, 1:500,000; by T. G. Gerdine, D. L. Reaburn, D. C. Witherspoon, and A. G. Maddren. In Bulletin 532. Not issued separately.

Noatak-Kobuk region; scale, 1:500,000; by C. E. Giffin, D. L. Reaburn, H. M. Eakin, and others. In Bulletin 536. Not issued separately.

O

Stanford University Libraries
3 6105 019 741 292

283410